CHEM. LIBRARY MAY 16 1922 CHEMICAL LIBRARY MAY 16 1922

VOL. 8. APRIL, 1922 NO. 31

MAY 16 1922

JOURNAL

OF

THE INSTITUTION

OF

PETROLEUM TECHNOLOGISTS

AND

RECORD OF TRANSACTIONS.

FOUNDED 1913—INCORPORATED 1914.

PUBLISHED BY
THE INSTITUTION OF PETROLEUM TECHNOLOGISTS,
3, JOHN STREET, ADELPHI, STRAND, LONDON, W.C. 2,
AND PRINTED BY
W. SPRAIGHT AND SONS, LTD.,
96–99 FETTER LANE, LONDON, E.C. 4.

PRICE 7s. 6D.

All rights of Publication or Translation are reserved.

W. J. FRASER & Co., Ltd.

ENGINEERS, DAGENHAM, ESSEX, ENGLAND

COMPLETE OIL DISTILLING AND REFINING PLANT SUPPLIED AND ERECTED.

ALL SIZES AND TYPES OF:

STILLS	AGITATORS
RETORTS	COOLERS
DEPHLEGMATORS	HEAT EXCHANGERS
CONDENSERS	TANKS, ETC.

CONSTRUCTED FOR ANY SPECIAL REQUIREMENT

Send for Catalogue, Section 10, J. P. T.

Sixty

Writt

Curre

Abst

Sixty-second Meeting :—

The Significance of the Interpretation of the Chemical Analyses of Seepages, by J. E. HACKFORD, B.S.C., F.I.C. 193

Written Communications :—

Note on Solubility of Benzene in Weak Alcohol, by W. R. ORMANDY and E. C. CRAVEN, Members 213

A Method for the Determination of the Vapour Pressure of Hydrocarbon Fuels, and the Estimation of Dissolved Air, by H. T. TIZARD and A. G. MARSHALL .. 217

When "Oil is Good?" By WILLIAM F. PARISH .. 224

Current Bibliography, compiled by W. J. WILSON, A.C.G.I., A.I.C. 230

Abstracts, compiled by S. BOWMAN, A.I.C. 260

* * *

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

NOTICES.

The Institution as a body is not responsible for the statements of opinions expressed in any of its publications.

Copyright. The entire contents of the Journal are covered by general copyright, and official permission is necessary for reprinting long abstracts; but editors may use not more than three pages of any paper, provided that credit is given as reproduced from the Journal of the Institution of Petroleum Technologists or advance-proofs thereof.

Issue of Journal. The Journal appears in four parts per sessional volume, viz., in January, April, July and October. A brochure describing the origin, progress and purposes of the Institution, and comprising also the Memorandum and Articles of Association, the By-Laws and Regulations of the Institution, the Library Catalogue to date (with subject index), and the List of Members, was published in September, 1915, to be followed periodically by revisions of the Library Catalogue and List of Members. The List of Members brought up to March, 1922, is now issued.

Members of all classes are entitled to receive these publications free; for additional copies of the Journal they will be charged at the price of seven shillings and sixpence per part, and of the brochures at the prices stated on the wrappers, varying in proportion to bulk.

Changes of Address. It is particularly requested that members notify the Secretary immediately of any change of address; and members are also requested to advise the Parcel Post Department, as well as the Letter Office, of any temporary change of address, as, unless this is done, parcel post packets will not be re-addressed, but will be returned to the offices of the Institution in London, thus incurring further expense for postage.

To Authors of Papers. Papers should be written in the third person and the copy should be carefully corrected by the author before it is presented.

All drawings, diagrams or other illustrations should be sent in a fit state for direct photographic reproduction.

All quotations, technical terms and localisms should be indicated by means of inverted commas.

Foreign weights, measures and costs should be given whenever possible, and also their English equivalents.

It is suggested that authors append as complete a bibliography of the subject treated as may be possible.

All papers and notes submitted to the Institution are supposed to be original communications unless distinctly stated to be otherwise, in which case the exact reference to the previous publication should be given.

Communications upon papers read at meetings, notices of personal movements, or other matter for which publication is desired in the next issue of the Journal, should be in the hands of the Editor on or before the last day of December, March, June or September, as the case may be. Subsequent delivery may be too late for insertion.

The Council desire to draw the attention of authors to the serious increase in the cost of production. Papers, both for the Journal and for communication to the Institution, should be as concise and condensed as possible.

Communications. The Council invite members to submit papers for the forthcoming session. Communications to the Institution will, subject to the approval of the Publication Committee, be published in the Journal.

Appointments Register. A Register will be kept at the offices of the Institution for the convenience of firms requiring the services of members and for members requiring appointments, but on the distinct understanding that the Institution accepts no responsibility and gives no guarantee.

Library. The Institution's Library at No. 5 John Street, Adelphi, may be consulted between 11 and 4 daily. Extensive additions are being made to the current and standard literature on Petroleum.

Additions since publication of last Journal :—

From the Imperial Mineral Resources Bureau :—

The Mineral Industry of the British Empire and Foreign Countries. War Period. Sulphur and Iron Pyrites.

From the Department of the Interior, U.S. Geological Survey :—

Bulletin No. 679. The Microscopic Determination of the Nonopaque Minerals. By Esper S. Larsen.

Bulletin No. 706. The Iron Ore Resources of Europe. By Max Roesler.

Bulletin No. 714. Mineral Resources of Alaska, 1919. By Alfred H. Brooks and others.

Bulletin No. 725B. Crome Ores in Pennsylvania, Maryland and North Carolina. By E. B. Knoff and J. V. Lewis.

Bulletin No. 725C. Deposits of Manganese Ore in Montana, Utah, Oregon, and Washington.

Bulletin No. 725D. Contact-Metamorphic Tungsten Deposits of the United States. By F. L. Hess and E. S. Larsen.

Bulletin No. 725F. Pyrite at the Haile Mine, Kershaw, S. Carolina. By Frank C. Schrader.

Bulletin No. 725G. The Taylor Creek Tin Deposits of New Mexico. By J. M. Hill.

Bulletin No. 725H. Ore Deposits of Cedar Mountain, Mineral County, Nevada. By A. Knoff.

Bulletin No. 725I. The Round Mountain District, Nevada. By H. G. Ferguson.

Bulletin No. 726C. Oil Prospects in Washington County, Utah. By H. Bassler and J. R. Reeside.

Water-Supply Paper No. 459. Colorado River Basin, 1917. By Nathan C. Grover, R. Follansbee, C. C. Jacob, and C. E. Ellsworth.

Water-Supply Paper No. 460. The Great Basin, 1917. By Nathan C. Grover and others.

Water-Supply Paper No. 471. North Atlantic Slope Drainage Basins, 1918. By Nathan C. Grover and others.

Water-Supply Paper No. 475. Hudson Bay and Upper Mississippi River Basins, 1918. By Nathan C. Grover and others.

Water-Supply Paper No. 476. Missouri River Basin, 1918. By Nathan C. Grover and others.

Water-Supply Paper No. 490B. Routes to Desert Watering Places in the Mohave Desert Region, California. By David G. Thompson.

Water-Supply Paper No. 500B. Ground Water for Irrigation near Gage, Ellis County, Oklahoma. By David G. Thompson.

Professional Paper No. 129B. Orthaulax, a Tertiary Guide Fossil. By C. Wythe Cooke.

Mineral Resources of the United States in 1920. (Preliminary Summary.)

From the Department of Mines, Mines Branch, Canada :—

Annual Report on the Mineral Production of Canada during 1920.

The Production of Coal and Coke in Canada, 1920.

The Production of Copper, Gold, Lead, Nickel, Silver, Zinc, and other Metals during 1920.

Report of the Department of Mines during the Fiscal Year ending March 31st, 1921.

Memoir No. 125, Geological Survey. Sedimentation of the Fraser River Delta. By W. A. Johnston.

The attention of members is drawn to the new supplement of the Journal which deals with current Petroleum literature. To make this section of the maximum usefulness it is necessary that there should be full co-operation between chemists, engineers and geologists, and that matter which has inadvertently escaped notice shall be immediately sent to the Editor. The Institution is indebted to Mr. W. J. Wilson for the compilation of the bibliography.

Advertisements in the Journal. A limited number of Advertisements of firms interested in the Petroleum Industry may be inserted in the Journal. Application for terms, etc., should be made to Messrs. Commercial Publicity Service, 58 Warwick Street, Regent Street, London, W.1.

LIST OF ADVERTISERS.

(Members are desired, when making enquiries or placing orders with advertisers, to mention that they have seen their announcement in the Journal.)

ANGLO-AMERICAN OIL CO., LTD.
ANGLO-MEXICAN PETROLEUM CO., LTD.
BRITISH PETROLEUM CO., LTD.
CHAPMAN & HALL, LTD.
W. CHRISTIE & GREY, LTD.
A. F. CRAIG & CO., LTD.
DUNN MANUFACTURING CO.
W. J. FRASER & CO., LTD.
A. GALLENKAMP & CO., LTD.
HAYWARD-TYLER & CO., LTD.
THE JAMES PRESS CO., LTD.
LUCY MANUFACTURING CORPORATION.
THE NATIONAL SUPPLY CORPORATION.
OIL ENGINEERING AND FINANCE.
OIL WELL SUPPLY CO.
VICKERS, LIMITED.
W. H. WILLCOX & CO., LTD.

PERSONAL NOTES OF MEMBERS AND SPECIAL NOTICES.

It is suggested that Members of the Institution send information regarding their movements to the Secretary for insertion under this heading.

Mr. E. J. THOMPSON has left for Venezuela to take up a position as mechanical engineer with Messrs. The British Controlled Oilfields, Ltd.

Mr. WILLIAM SUTTON returned from the United States in January

Mr. F. D. BROWN has left for Minatitlan.

Mr. F. E. CHERRY has returned home from Venezuela.

Mr. T. R. H. GARRETT has joined the staff of Col. F. Johnson, Sons and Co., at Rangoon.

Major W. GROUNDWATER is with Messrs. The Union Petroleum Products Co., at Birmingham.

Mr. B. F. N. MACRORIE is at present in England.

Mr. R. G. NEILSON is now at home again.

Mr. N. SUTHERLAND is with the staff of the Anglo-Persian Oil Co., in the Persian Gulf.

Mr. T. A. AMBROSE has joined the staff of the National Oil Refineries, Ltd., Skewan, S. Wales.

Mr. F. E. KEEP is at the Sangareni Collieries, Sangareni, Deccan, India.

Sir JOHN CADMAN has returned home from America.

Mr. JOHN CLARK TEMPLETON is with the Bitumen Company, Zagreb, Croatia, Yugo-Slavia.

Mr. JAMES CLARK TEMPLETON has joined the London staff of the D'Arcy Exploration Company.

Mr. H. BARRINGER returned from the States in February.

Mr. KENNETH WATTS has left for the Argentine.

Mr. ALBERT MILLER has started business as a Consulting Mining Engineer in Boryslaw, Poland.

Mr. FRED ESLING has opened a laboratory as a Consulting Chemist and Petroleum Technologist in London.

Dr. A. E. DUNSTAN and Dr. F. G. REMFRY have returned from the United States.

Mr. A. W. IBBETT has returned to Trinidad.

Mr. J. E. MARSHALL HALL has returned from Africa.

Mr. R. P. BOLTON is with the Romano-Americana Company at Ploesti, Rumania.

Mr. F. G. RAPPOPORT, who has just returned from Angola, Portuguese West Africa, has been appointed adviser on petroleum matters to the Government of Siam.

OBITUARY.

MR. JOHN SMART SMITH.

IT is with great regret that we have to record the death of Mr. John S. Smith, which took place at Aberdeen on December 23rd last, after an illness of three months, and the Council tender

to his family their sincerest sympathy in their irreparable loss.

He was born at Perth on November 24th, 1873, and educated at Perth and the Robert Gordon's College at Aberdeen. At the age of sixteen he commenced an apprenticeship with Messrs. Clyne, Mitchell & Co., Ltd., Marine Engineers, of Aberdeen, supplementing his practical training with theoretical studies during a period of six years.

In order to become more thoroughly acquainted with engineering practice, he joined Messrs. Cayzer, Irvine & Co. as a seagoing engineer, and made rapid progress through the various grades until he obtained his chief engineer's certificate, when indifferent health caused him to abandon the sea.

He was then engaged on the staff of the Harbour Engineer at Aberdeen for three years on general construction and maintenance work, and in 1903 obtained a post with Messrs. S. Pearson & Son, Ltd., on their staff at Malta, at the time they were constructing the new docks and harbour at that port.

After a short time Viscount Cowdray, then Sir Weetman Pearson, required his services in connection with oilfield and refinery developments which he had just undertaken. From then until his death he was associated with the Mexican Eagle Oil Co., Ltd., which was founded by Lord Cowdray to carry out work in Mexico. He contributed his full share to solving the many difficult problems which arose from time to time during the progress of this important venture, and the untimely loss of so valuable an assistant has no doubt been very keenly felt by his chief.

His responsible work in connection with the Mexican Eagle Oil Co. necessitated his visiting Mexico and the United States frequently, and he acted as refinery manager at Minatitlan and general manager at Tampico.

He bore a large and responsible part in the work connected with the construction of the fleet of tank steamers built for Messrs. The Eagle Oil Transport Co., Ltd., and was a director of that company.

Various other interests of his firm engaged his attention. He was a director of the Whitehall Petroleum Corporation, Ltd., and of the Thames Land Co., Ltd.

He was a member of Council of the Institution of Petroleum Technologists, a member of the American Society of Mechanical Engineers, an associate member of the Institution of Mechanical Engineers, and a member of the Consultative Committee on Petroleum Technology of the Sir John Cass Technical Institute.

His death is a loss to the Petroleum industry of this country. His knowledge of the engineering side was extensive and thorough,

and his opinion on any matter connected therewith was always valuable. He will be greatly missed by his many immediate colleagues, and by a large circle of friends, who will always remember his kindly and generous nature.

SAMPLING AND ANALYSIS OF COAL COMMITTEE.

THE Fuel Research Board of the Department of Scientific and Industrial Research have appointed a Committee to advise upon the sampling and analysis of coal. The personnel of the Committee is as follows :—

Professor Thomas Gray, D.Sc., Ph.D. (*Chairman*).
Professor J. W. Cobb, C.B.E., B.Sc.
J. T. Dunn, D.Sc.
J. S. Flett, O.B.E., D.Sc., LL.D., F.R.S.
G. Nevill Huntly, B.Sc.
S. Roy Illingworth, M.Sc.
J. G. King, F.I.C.
C. H. Lander, D.Sc.
R. Lessing, Ph.D.
C. A. Seyler, B.Sc.
F. S. Sinnatt, M.B.E., M.Sc.
Professor R. V. Wheeler, D.Sc.
Secretary: Miss N. Renouf, F.C.S.

It is intended that the methods recommended by the Committee shall be adopted in connection with the Physical and Chemical Survey of the National Coal Resources.

Communications for the Committee should be addressed to the Secretary, at 16 & 18, Old Queen Street, Westminster, London, S.W. 1.

PHYSICAL AND CHEMICAL SURVEY OF THE NATIONAL COAL RESOURCES.

THE Fuel Research Board have made arrangements for the recognition of the Lancashire and Cheshire Coal Research Association as the local Committee working under the Board for the purpose of dealing with the physical and chemical survey of the coal seams in this area. The Chairman of the Committee is Mr. Robert Burrows, and the Director of Research, Mr. F. S. Sinnatt.

It has long been felt that an important aspect of the great problem of the conservation of the national coal resources involves the study and classification of the coal seams which are at present being worked or developed, and also of seams or portions of seams which are being left unworked or are thrown aside above or below ground. This study and classification on its directly practical side must deal primarily with the suitability of each particular coal for those purposes for which its individual qualities render it most adequate, *e.g.* for gas making, coke making, steam raising or for domestic use.

This question of survey has for some years been receiving the anxious consideration of the Fuel Research Board, but the unstable conditions which prevailed in the coal industry during and since the war have necessarily led to the postponement of the work of organisation. It is now, however, considered that the time has arrived when a beginning can wisely be made.

The Fuel Research Board believe that this work can be most effectively carried out with the help of local committees in which colliery owners, managers and consumers are associated with the representatives of the Fuel Research Board and the Geological Survey. By this combination not only will local knowledge and experience be made available, but the initiative of those most deeply interested in the practical aspects of this survey will be secured.

The survey work will thus from the outset assume a practical character, for the selection of seams for examination will be in the hands of those who are in the best position to estimate the relative importance of the problems awaiting solution. The selected seams will be submitted to physical and chemical examination by the local experts; and, as a result of this examination, a further selection will be made of those which appear to justify experiments on a practical scale to test their suitability for particular uses or methods of treatment. This experimental work will be carried out either at H.M. Fuel Research Station or at other works, as may be found most convenient.

The first Committee is already actively at work in the Lancashire and Cheshire district, where the local Research Association has been recognised by the Fuel Research Board as its representative body for the purpose. It is felt by the Fuel Research Board that the experience gained in the work and organisation of this Committee will be of great value in the establishment of Committees in other districts when the time is ripe for further developments, but they are satisfied that it will be wise to build up this national organisation on the sure foundations of actual experience.

"PETROLEUM REFINING:"

It is with considerable interest that we notice the announcement of the Second Edition of Campbell's *Petroleum Refining* (Griffin and Co.). It is the fate of a great number of technical manuals never to survive the first edition; it is therefore all the more pleasing to notice that Mr. Campbell's book has not only been the pioneer in this subject in the English language, but promises to become the classical work of reference on Refining.

FUEL FOR MOTOR TRANSPORT.

THE Second Memorandum by the Fuel Research Board on "Fuel for Motor Transport" has been issued and can be obtained from H.M. Stationery Office, Imperial House, Kingsway, W.C. 2. Price 6d.

To those of the public who expect to learn that there is an immediate prospect of alcohol being able to compete with petroleum product in the fuel market, the report will be a disappointment. But to those who are acquainted with the real facts of the situation the report will appear as a clear and concise statement of the actual position of affairs. It points out that if all the molasses produced from the whole of the sugar made in the British Empire were converted into alcohol only 15 million gallons would result. Great weight is laid upon the value of experimental work dealing with the possible conversion of cellulose material into fermentable products, but it states that from the economic standpoint the problem is not yet solved. The production of alcohol from acetylene produced from calcium carbide is dealt with, and the conclusion arrived at that calcium carbide can only be made under the most favourable conditions, only obtaining in certain colonies at a price which would render the production of alcohol therefrom a commercial proposition. It is pleasing to note that statistics throughout are given in 95 vol. per cent. alcohol, which is what the fuel user understands by alcohol, and that when dealing with vegetable products yields are converted into gallons per acre. This makes the figures understandable by a much larger audience. The conclusion that alcohol production from cultivated crops is only possible in sub-tropical countries, where cheap labour is available. is emphasised, and those colonies where conditions are suitable and liquid petroleum fuel is expensive should be encouraged by the report.

W. R. O.

The Sixty-first Meeting of the Institution of Petroleum Technologists was held at the House of the Royal Society of Arts, John Street, Adelphi, W.C., on Tuesday, January 10th, 1922, Prof. J. S. S. Brame, President, occupying the Chair.

The following Members of Council were present:—Sir Frederick W. Black, Sir Thomas H. Holland, Mr. Alexander Duckham, Mr. Arthur W. Eastlake, Dr. W. R. Ormandy, and Mr. T. C. Palmer.

The following paper was then read:—

An Investigation into the Physico-Chemical Significance of Flash-Point Temperatures.

The question of the flash-points of combustible bodies, more particularly petroleum oils, is one which has been treated as of legal importance rather than of scientific value. Flash-points have not usually found a place beside physical constants in the tables of the properties of bodies. J. A. Harker and W. F. Higgins (*Collected Researches*, National Physical Laboratory, 1912, 8, 38), after a long research into standard methods and apparatus used in petroleum testing arrived at the following conclusion: "It must be recognised that the flash-point of a liquid as ordinarily determined is an empirical constant, which is largely a function of the particular apparatus employed. It would seem desirable, therefore, to establish, if possible, more definite connection between this property and the real physical properties of the substance." They then state their intention of comparing the flash-point of various liquids with their vapour tensions, but we have not been able to trace any report of this work.

No doubt this idea of the flash-point being an empirical figure rather than a true physical constant has arisen from the fact that the greater portion of work done on this subject centres around the flash-point of a complex mixture, namely, kerosene and instruments for this determination. In this way an air of—one might say—empiricism has been thrown over the whole question of flash-points, and it is perhaps owing to this trend of feeling that research in this direction has been so neglected. This feeling has also made physicists somewhat shy of using the term "flash-point," and where such points have been determined they are not referred to specifically as such. Some determinations of the flash-point of alcohol were made both by Le Chatelier and by Eitner, but the figures are not given as such but are, as it were, concealed as portion of a determination of the limits of explosibility of air with alcohol vapour.

It must be obvious, however, that especially in the case of pure bodies a knowledge of the flash-point and of the vapour pressure suffices to give the composition of the vapour at the limits of flame

propagation, there being, of course, two flash-points for each liquid, the upper and the lower, corresponding to the composition at the two explosive limits. In this connection, therefore, it would seem that flash-points, and the deductions to be made therefrom, are really of considerable interest both from the theoretical or pure scientific standpoint and also from the practical application to the processes occurring in the carburettor and explosion chambers of internal combustion engines.

Some time ago we had occasion to determine the flash-points of a number of organic bodies. The determinations were made with a

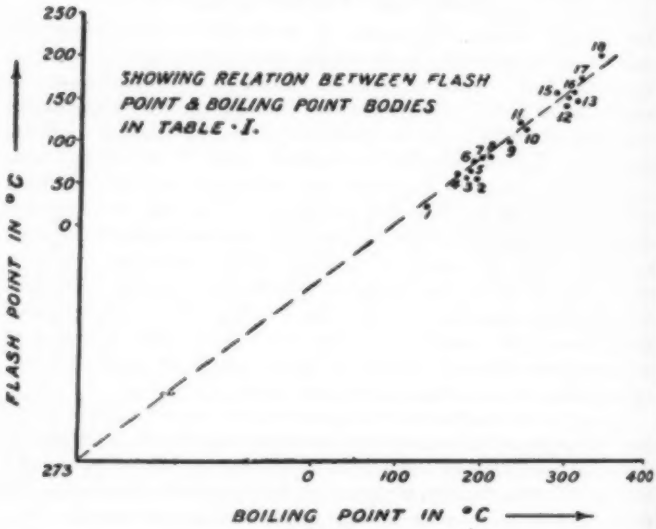


Fig. 1.

Pensky-Marten tester in the usual manner. We were led to plot the results against the boiling-points in order to test if there were any relationship between the two properties. The remarkable result was found that there appeared to be an approximately linear relation between the flash-and boiling-points as is shown in Fig. 1. It appeared also that the relation may be expressed roughly in the form :—

$$\text{Flash-point } °K \times \text{constant} = \text{boiling-point } °K.$$

The table below gives the results obtained for the bodies for which points are given in Fig. 1, where the constant in the above equation

is given in the column marked R. In the last column is given the vapour tension of each body as found by reference to the Landolt-Börnstein tables.

TABLE I.

No.	Substance.	F.P. °C.	B.P. °C.	R.	Vap. press. mm. Hg.
1.	Monochlor benzene	29	132	·746	14
2.	Dimethylanilin	61	192	·720	5
3.	Benzaldehyde	62·5	179	·742	10½
4.	p-dichlorbenzene	67	172	·764	—
5.	Anilin	71	184	·752	11½
6.	O-cresol	81	188	·768	12
7.	O-toluidine	87	197	·766	13
8.	Nitrobenzene	89	208	·754	12½
9.	p-nitrotoluene	106	230	·754	10
10.	Benzoic acid	121	249	·756	—
11.	p-nitrochlorbenzene	127	242	·778	—
12.	m-dinitrobenzene	>150	297	>·743	—
13.	Di-phenylamine	153	310	·738	—
14.	a-naphthylamine	157	300	·751	—
15	β-naphthol	161	286	·776	—
16.	a-nitronaphthalene	164	304	·759	—
17.	Di-nitrochlorbenzene	187	315	·782	—
18.	Di-anisidin	206	338	·784	—

Our attention was drawn to the constancy of the ratio R, which is all the more surprising considering the variety of the bodies tested. It should be pointed out also that the boiling-points were not determined, but are those of the pure bodies. As will be apparent later, this introduces a source of error. The approximate constancy of the vapour pressures (with the exception of dimethylanilin) may also be noted, as we shall return to this point later.

The question of flash-points was taken up again in connection with work on the alcohol solubility of hydrocarbons being carried out for the Distillers Co., Ltd.* As this work was being carried out down to low temperatures it was thought desirable to devise some form of apparatus suitable for use at these reduced temperatures and upwards over any desired range. In considering this question it appeared to us that the usual types of flash-point instruments possessed several

* Portions of this work have already appeared in the Journal, Oct., 1921, and Dec., 1921.

grave defects which militate against their being regarded as of true scientific design. These defects we may enumerate as under :—

1. The vapour space is unevenly heated, the top surface being exposed to cooling by the air.

2. Loss of vapour is liable to occur when the test flame is introduced through open ports in the lid.

3. The instrument can only be used for lower flash-points.

Other objections on the score of convenience also influenced us, such as the large bulk of liquid required (which is a consideration in dealing

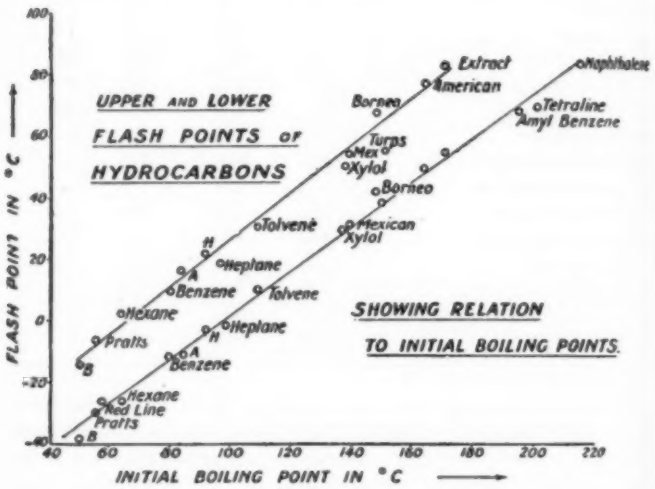


Fig. 2.

with somewhat rare bodies) and the awkward nature of the tester if it were required to be used at reduced or increased pressure. The form of apparatus arrived at after some trials is shown in Fig. 2—a description is attached to the sketch. In another form tried the bell tube was replaced by a straight tube of $\frac{7}{8}$" diameter and 10" long. The ignition was effected by sparks produced by a high-tension magneto worked by hand. Care was taken to restrict the number of sparks passed to a minimum in order to avoid using up the oxygen present in the combustion space. Two forms of spark gaps were tried, one consisting of 3 mm. steel balls $\frac{1}{2}$ to 1 mm. apart, and the other of the rough cut

ends of 1 mm. nickel wires ½ to 1 mm. apart. It was found that the balls gave very uncertain results, the flash hanging fire in many cases until the temperature was several degrees above the normal flash-point, so that the flash was very violent. By repeating observations, however, a minimum could be found which was taken as the true flash-point. The wire-points, however, gave very easy and definite ignition. The results obtained by means of various types of apparatus are compared in the table below :—

TABLE II.

Flash-points in °C.

Material.	Pensky-Marten gas flame ignition.	Straight tube points.	Bell tube steel balls points.	
American kerosenes . .	47	45	49	48½
Borneo kerosene . .	40	38½	42	42
Edeleaun extract from above	53½	52	55	54½
Mexican kerosene . .	29½	28	31	31
Xylol	28	27	29½	29

Further work with the straight tube showed that especially at low temperatures the results were extremely erratic, and on this and other accounts it was abandoned. It would have been preferable, of course, to employ an Abel rather than a Pensky-Marten tester, but the former was not available at the time these particular tests were carried out.

Further opportunity for observing the effect of different kinds of spark has since arisen, and the observations show that if the spark-points are approximately 1 mm. apart and a "fat" spark employed, the flash-point determinations agree to 1° C. For example, the following figures have been obtained :—

Sample.	Magneto ignit.	Coil ignit.
Kerosene extract . .	49	48
Xylene	29	30
Butyl alcohol . . .	38	37
Amyl alcohol . . .	44	45
Anilin	77	76
Hexahydroxylene . .	11	11
Naphthalene . . .	84	83
Turpentine . . .	36	36

If the spark, on the other hand, be feeble, as usually arises when the points are made to approach closely, or weak from any other cause, the flash " hangs fire " several degrees, and when it finally occurs it is very violent, giving a loud report. This is a sure sign that the true flash-point has been passed, the normal flash being a mild affair. In this manner errors arising from an unsuitable spark are at once detected.

Experiments have also been made to determine if the flash-point is affected by the number of sparks used. A Mexican kerosene having a normal flash of 31° C. was heated at 4° C. below this temperature. Twenty sparks were passed and the flash-point was then found to be 31° C. after four more sparks (one test each 1° C.). In a similar manner forty sparks raised the observed flash 1° C. Heating the kerosene at 2° C. below its flash-point twenty sparks showed a rise of 1° C. and forty sparks 2° C. Other observations were collected in performing duplicate tests. Thus observed flash-points on alcohol-benzene mixtures were: thirteen sparks 8° C., seven sparks 8° C., and on another sample seven sparks 11° C., one spark 12° C. Propyl alcohol: six sparks 25° C., three sparks 24° C., one spark 24° C. From these figures it appears that one spark per 1° C. temperature rise cannot introduce greater errors than 1° C.

Some tests have also since been made with an Abel tester and the following figures obtained :—

Sample.	Abel.	New apparatus.
Kerosene extract . . .	44° C.	49° C.
Kerosene American . .	55° C.	58° C.
Turpentine . . .	33° C.	36° C.
Anilin	76° C.	76½° C.
Naphthalene . . .	83° C.	83½° C.
Butyl alcohol . . .	37° C.	38° C.

One reason for the difference between the results obtained with the new apparatus and the Abel or Pensky-Marten's type of tester may be referred to here briefly. It lies in the fact that the ratio of the vapour space above the liquid to the volume of the latter is much smaller in the case of the standard instruments. In the Abel tester the ratio is about seventy liquid to thirty vapour, whilst in the new tester it is more of the inverse order. Thus more liquid has to be vapourised in order to give an explosive mixture, and in the case of a complex mixture this corresponds to an increased temperature.

It follows from this that pure liquids should not show this difference, and, in fact, it will be noticed from the figures already given that the differences in the case of nearly pure bodies is very much smaller.

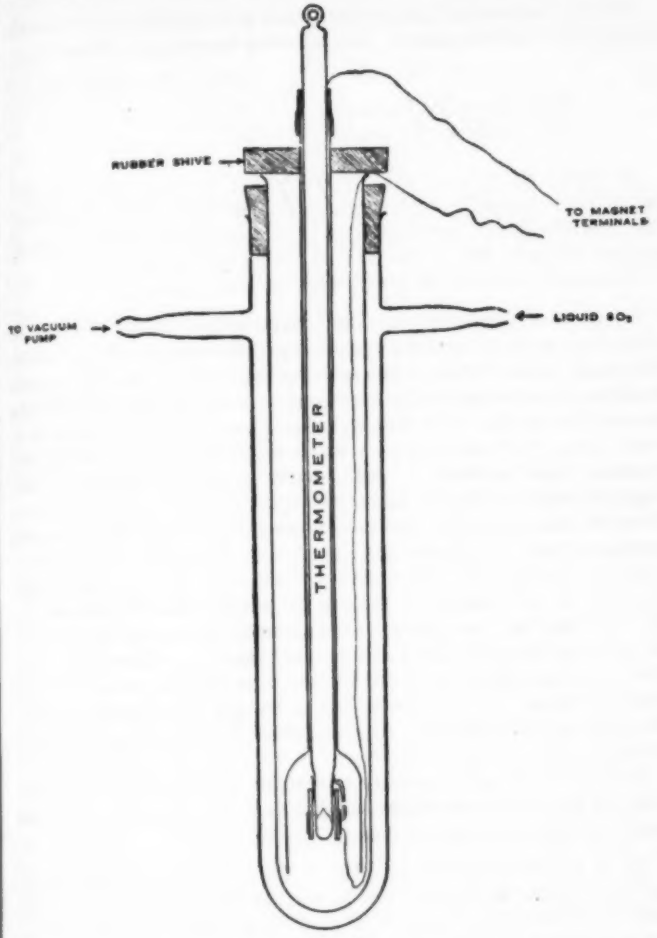


Fig. 3.

Consists of a bell-shaped glass tube which is supported by a shive as shown in an $8'' \times 1''$ test tube. The thermometer passes down through the bell tube as shown, and is backed with thin tinfoil, making connection with the high tension terminal of the magneto and with the spark-gap arrangement. The spark-gap consists of two concentric cylinders of copper foil to which are soldered the 1 mm. nickel-wire points. The two cylinders are insulated by a short piece of glass tubing. Before making a test the bell is lined with a rectangular piece of filter paper, leaving a $\frac{1}{4}''$ clear strip through which to observe the spark, etc.

The new apparatus is, of course, much less sensitive to very small quantities of volatile bodies. The following figures show this :—

	Abel.	New Apparatus.
Flash of straight kerosene .	55° C.	59° C.
Flash of ditto—0·1 pentane .	50° C.	57° C.

It should be pointed out, however, that the test with the new apparatus is probably much more nearly a criterion of the liquid from the fuel standpoint, the conditions as to relative air volume being of greater similarity than in the Abel or similar instrument.

The method of using the new instrument is as follows :—

(*a*) *At Low Temperatures.* The instrument is cleaned, dried, and assembled, a dry piece of filter paper being placed in the bell. 7 cc. of the liquid to be tested is run into the tube which amounts is just sufficient to saturate the filter paper and to cover the bell. Liquid SO_2 is now run into the outer tube and distilled away in the vacuum of a water pump as mentioned in a previous paper on the solubility of aromatic hydrocarbons in alcohol-water mixtures (*Journal*). The liquid is cooled well below the anticipated flash-point, and the vacuum then reduced or cut off so that the temperature after a time commences to rise at the rate of some 1° C. per minute. At each degree rise a spark is passed. The liquid may be stirred gently by raising and lowering the bell tube or by shaking the whole apparatus round. At the flash-point a mild explosion occurs, usually accompanied by a flash of pale blue flame.* The bell tube may jump a centimetre or two, hence a rubber shive is provided to prevent it breaking the containing tube. Bubbles of gas are forced out of the bell and the thermometer rises about 2° C. suddenly. After the flash the bell is found half-full of liquid.

It has been thought necessary to describe these indications in such detail as the flash is sometimes so feeble as to leave considerable doubt as to whether it has really occurred.

(*b*) *At Higher Temperatures.* Up to the present no determinations have been made higher than can be reached with a water bath. The tube is immersed to a depth of 4″ to 5″ in a beaker of air-free water which is heated by a tiny flame, so a difference of about 2° C. is maintained between the bath and the vapour space. This corresponds to a rate of temperature increment of some 1° C. per minute. The flash-point is dependent on the rate of rise to some extent as shown by the following figures on a kerosene :

* In the case of alcohol the flash is practically non-luminous.

Temperature difference	Observed flash.
.2° C.	40½° C.
3° C.	42° C.
3½° C.	42°, 42° C.
4° C.	41° C.

In regard to flash-points at low temperatures the only figures we have been able to find in the literature are on various petroleum fractions as under (Holde, *Examination of Hydrocarbon Oils*, 1915).

B.P.	50–60° C.	60–78° C.	70–88° C.	88–100° C.	100–115° C.
Flash	−58	−39	−45	−22	10

The results found with the present apparatus are given in the tables under. Many of the examples tested are as used by Mr. Ricardo in his recent work. For details of preparation of other bodies see Appendix.

Kerosene— Sample.	Initial B.P.	Low Flash.	High Flash.	R_1	R_2
American 1	165° C.	48½	76½	·734	·797
American 2	166	49	77	·734	·797
Borneo	148° C.	42	68	·748	·890
E. Extract	170° C.	54½	83	·740	·804
Mexican 1	140° C.	31	56	·736	·797
„ 2	139° C.	30	—	·735	
Petrol Spirits—					
Pratt's No. 1	57° C.	−28	—	·744	——
„ „ (2nd sple.)	55° C.	−32	− 7½	·736	·811
Red Line	58° C.	−27	− 4	·744	·814
Shell	63° C.	−25	½	·738	·814
A	84° C.	−10½	16	·736	·810
B	50° C.	−39	−14	·725	·804
E	57° C.	−30	− 6	·736	·810
F	57° C.	−30	− 7	·736	·807
H	92° C.	− 3	21	·739	·807
Paraffins—					
Hexane (64–71)	64° C.	−26	1	·734	·813
„ Ricardo 1	62° C.	−30½	—	·726	—
„ „ 2	62° C.	−30	—	·727	—
„ „ 3	64° C.	−31½	—	·718	—
Heptane (pure)	98° C.	− 1	17	·734	·783

Aromatics–						
Benzene	80° C.	−12(solid)	10	·739	·802	
Toluene	109° C.	10	30	·743	·794	
Xylol	138° C.	29	50	·735	·787	
Naphthalene	218° C.	86	—	·732	—	
„ (2nd sple.)	215° C.	84	—	·732	—	
Amyl benzene	195° C.	69	—	·731	—	
Hydro Aromatics, Naphthenes—						
Cyclo hexane	79° C.	−17(solid)	—	·728	—	
Methyl cyclo hexane (H.H.T.)	95° C.	− 4	—	·731	—	
Hexa hydro xylene	118° C.	11	—	·727	—	
"Tetraline" (middle fract.)	201° C.	70	—	·725	—	
Tetraline (crude)	132° C.	39	—	·770	—	
Alcohols–						
Methyl	64° C.	− 1	32	·809	·906	
Ethyl	78° C.	11	32	·810	·870	
Propyl	95° C.	24	45½	·808	·867	
Butyl	116° C.	38½	58	·801	·852	
Amyl	128° C.	44	66	·790	·777	
Miscellaneous—						
Industrial alcohol (5% benzol)		1	—	—	—	
Alcohol motor fuel	72° C.	−12	17	·758	·842	
Turpentine	150° C.	38	55	·736	·775	
Acetone	56° C.	−18	2	·777	·837	
Bone oil	125° C.	52	—	·816	—	
Caoutchoucine	109° C.	26	—	·783	—	
Ether (methylated)	35° C.	−41	—	·754	—	
„ (pure)	34° C.	−41	−27	·756	·802	
Turpentine (fraction 156–58)	36° C.	—	—	·720	—	

It was intended at the outset, in the case of pure liquids, to plot the flash against the true-boiling-points. The ratio thus found was very close in all cases to 0·734. In the case of mixed liquids it was necessary to consider what meaning was to be attached to the term "boiling-point." On examining the figures obtained for mixed liquids such as petrols and kerosenes, it appeared that this ratio was obtained if the

"first drop" temperature from the condenser end in an Engler distillation was taken as the boiling-point. This is to be expected seeing that with our type of apparatus some $\frac{1}{10}$ to 1 per cent of the liquid must be evaporated before an explosive mixture is obtained. It was then found better to adopt the "first drop" temperature in all cases for the sake of uniformity. Of course, with pure liquids the "first drop" temperature should be equal to the true boiling-point. As a matter of practice, however, it is a very tedious matter to refine liquids to anything like this state of purity, and in general the drop-points of our "pure" samples were seldom less than 1° C. below the mean boiling-point. For the figures, as already mentioned, reference must be made to the Appendix.

This question of boiling-point range is closely bound up with the differences in the observed flash-points with various types of instruments. In the case of pure liquids where the range should be nil the same results should be obtained whatever the ratio of the vapour space to the liquid volume, as we have already shown.

When, however, the liquid has a steep distillation curve great differences may be noted; this has the effect of raising the constant R as determined by the new apparatus. As an example we may take a sample of "tetraline" (tetra-hydronaphthaline).

The Engler distillation showed the following figures:—

Drop 132° C. 1% over at 144° C. 2% over at 155° C.
5% „ 171° C. 10% „ 184° C.

This sample gave Abel flash 33° C. R = ·756.
New apparatus 39° C. R = ·770.

A middle fraction was distilled out coming over from 201° C. to 203° C., and this gave a flash in the new apparatus of 70° C., corresponding to a more normal ratio of ·724 if 201° C. be taken as the drop temperature. We had not enough sample, unfortunately, to determine the true drop, but there is not the slightest doubt it would have been 2° or 3° C. lower than 201° C., giving the usual value of R, namely 0·736.

We thus see that a very steep distillation curve, particularly with a liquid of high molecular weight, is liable to give a flash temperature not agreeing with the drop temperature even where the latter is correctly determined. On the other hand, we have found cases where the error lies in the drop-point determination. We refer here to the well-known fact that many hydrocarbons and other liquids contain dissolved gases sometimes in very considerable amount. We have had samples of pentane having exactly the same distilling range as determined by the Engler test, but the distillation loss, in one case 20 per cent

against 5 per cent in the other. The loss in refluxing commercial ether is well known in chemical works. During the course of the present work an attempt was made to purify hexane by distillation. The original material had a flash of $-31\frac{1}{2}$° C. and drop point of 64° C. As the fractionation proceeded it was found that the bulk material separated retained the same drop temperature, but the flash-point rose steadily to −26° C., corresponding to a change in R of from 0·718 to 0·734. This is undoubtedly due to the gradual separation of dissolved gases in the course of the purification, and there is no doubt that after extremely protracted fractionation R would have become 0·736. (It should be mentioned that a whole week had already been spent in endeavouring to separate out pure hexane, but a 64—71° C. fraction was the best we could do without resorting to the troublesome fuming nitric treatment.)

Besides the liquids above mentioned, which are of a light character and therefore might be expected to retain some gas, we have also considerable evidence that such an unlikely body as commercial kerosene may contain such an amount of dissolved inflammable gas as to lower the flash-point by 12° F. Work is still in progress on this subject, but the case of an American kerosene examined by one of the Institution's student members, Mr. Banks, showed the following figures. The drop-point of the kerosene was 171° C., corresponding to a flash-point according to the 0·736 factor of 129° F. In the Abel tester the flash, however, was observed to be at 118° F. After "tossing" a sample of the kerosene the drop-point was found to be unchanged, but the flash had risen to 129° F. The same result was obtained by bubbling air through the kerosene when it was found that a loss of 0·1 per cent by weight was accompanied by the 11° F. rise in flash before noted, and further bubbling had very little effect. As a further proof of the gaseous nature of this dissolved material it was found that the addition of 0·1 per cent of pentane (boiling 32–44° C.) only lowered the flash of tossed kerosene by 9° F. In the new tester the flash shown was 129° F., showing that the amount of gas present, being below 0·1 per cent by weight, is insufficient to affect the flash-point as determined by it. Had the amount of gas been larger, however, there is no doubt that it would have affected the result. In general, therefore, there are two sources of error in considering the relation of flash-point to boiling-point.

1. Steep distillation curve leading to high values of R.
2. Dissolved gases leading to low values of R.

Making allowance for these disturbing factors, therefore, what we have found is that the flash-point of any hydrocarbon is a linear

function of its boiling-point. Stating this in the form of a law we would submit that this research has shown :

For any hydrocarbon or any mixture of hydrocarbons, not containing small quantities of volatile impurities, in contact with air, the limiting temperatures at which explosive mixtures are formed are constant fractions of the initial boiling-point.

The constant fractions for the two limits which are, of course, the lower and upper flash points are as follows :—

Lower flash-point °K. = 0·736 × Initial boiling-point °K.
Upper „ „ °K. = 0·800 × „ „ „

In Fig. 2 the flash-points of various hydrocarbons have been plotted against their initial boiling-points, and it will be seen that within the limits of experimental error the points, with few exceptions, lie on straight lines corresponding to the above equations. The exceptions appear to be in the upper limit only and are for heptane, xylol, and turpentine. The case of heptane has been thoroughly tested, samples being specially purified. The following values for the upper flash having been obtained,

Heptane said to be of vegetable origin—19, 17° C.
„ „ mineral „ 17, 16½° C.

The other two cases have not been examined so thoroughly, but it is noteworthy that amongst the hydrocarbons examined by Ricardo, heptane and turpentine gave peculiar results. Turpentine is also remarkable in that its temperature of spontaneous ignition (Moore) is the same in air and oxygen.

Passing from the pure hydrocarbons to the alcohols we find that these bodies on a similar graph fall on curves roughly parallel to the hydrocarbon curves. The alcohols thus preserve their individuality in respect of flash-point as they do in most other properties. It will be noticed, however, that whereas with hydrocarbons the ratio

$$\frac{\text{T flash-}}{\text{T boiling-point}}$$

is a constant for all the bodies so far investigated, with the alcohols the ratio steadily diminishes. Thus if we take the lower flash-points there is an approximately steady difference of 25° C. in flash between the hydrocarbons and the alcohol curve. The constant R for the alcohols is thus given by the equation

$$R = \frac{T_{HY} + 25}{T_{BP}} = 0{\cdot}736 + \frac{25}{T_{BP}}$$

where T_{HF} is the absolute flash temperature of a hydrocarbon having the same absolute B.P. (T_{BP}) as the alcohol in question.

From this it follows that as the boiling-point of the alcohols rises the constant R approaches more and more closely to that of the hydrocarbon series. This, of course, is what might have been expected, seeing that as n in the paraffin and alcohol general formulæ becomes greater the less is the difference in composition or corresponding members of the two series.

A small amount of work has been done varying the conditions in the apparatus. The determinations under pressure or in oxygen are not easy to carry out and are rather severe on the apparatus, the "flashes" being sometimes rather violent. The following results have been obtained :—

Flash-points in oxygen.

	In air.	In oxygen.
Mixed motor fuel .	−12	−27
Petrol A . .	−10½	−30

The petrol gave a loud report and carbon was deposited.

Flash-points under varying pressure :—

A kerosene was taken having a flash-point under normal pressure of 31° C. Various air pressures were applied and the flash determined. The following results were obtained :—

Press. mm. Hg. above atmos.	Flash.
0	31° C.
51	33°, 33°, 33½° C.
76	34°, 34½° C.
102	35°, 36° C.

If these results be graphed it will be found that the flash-point increases at the rate of 1° C. per 26 mm. Hg. increase of pressure. The drop of this kerosene was 140° C. Calculating from the formula given by Young (*Fractional Distillation*, p. 14) the pressure difference for 1° C. change in B.P. of a hydrocarbon boiling at 140° C. we get 20 mm. Thus we find that a pressure sufficient to raise the B.P. by 1° C. only raises the flash by $\frac{20}{26} = 0{\cdot}77°$ C. This, of course, is our constant R.

It is interesting to note that the above value for the correction of flash-points amounts to 1·7° F. per 1″ of mercury, the legal value being 1·6° F. based on the experiments of Sir Fred. Abel. Some experiments

made in Germany gave the correction as 0·3° C. per 10 mm. Hg. equivalent to 1·4° F. per 1°.

On binary mixtures the following determinations have been made :—

ETHYL ALCOHOL AND WATER.

Alch. Per cent wt.	Flash.
99·6	11° C.
98·1	11½° C.
97·2	13° C.
95·9	14½° C.
94·9	15° C.
93·8	15½° C.
91·9	16° C.
91·0	17° C.
90·0	16½° C.
89·9	16° C.
85·0	17½° C.
80·1	18½° C.
75·4	20½° C.

BINARY MIXTURES.

95 per cent vol. alcohol and benzene.

Per cent vol. Alch.	Per cent vol. Benzene.	Flash.
100	0	16½° C.
75	25	— 8° C.
50	50	—12° C.
25	75	—12° C.
0	100	—12° C.

ALCOHOL—BENZENE—KEROSENE MIXTURE WITH ETHER.

Per cent vol. Ether.	Flash.
0	— 3° C.
5	— 8° C.
10	—12½° C.
20	—18½° C.
40	—27½° C.
60	—33½° C.
80	—37½° C.
100	—40° C.

ETHER—ALCOHOL (95 vol. per cent).

Per cent vol. Ether.	Flash-Pt.
0	15½°
10	—10°
20	—21°
30	—28½°
50	—35°
70	—38°
100	—41°

BENZENE—HEAVY PETROL.

Per cent vol. Benzene.	Flash.
0	—11½° C.
10	—12° C.
20	—14° C.
40	—15° C.
50	—15° C.
60	—14° C.
100	—12° C.

BENZENE—TOLUENE.

Per cent vol. Benzene.	Flash.
0	+10° C.
10	5° C.
20	2° C.
40	— 3° C.
50	— 5° C.
70	— 8° C.
100	—12° C.

The above results on petrol spirit were repeated, using Red Line Petrol from which the fractions boiling below 83° C. were taken off, and National Motor Benzole. The flash-point and distilling range of the liquids and three mixtures were determined.

Per cent vol. Petrol.	Per cent vol. Benzole.	Flash-point.
100	0	−10½° C.
75	25	−13½° C.
50	50	−13½° C.
25	75	−13° C.
0	100	−11° C.

ENGLER DISTILLATION.

	Petrol.	25% Benzole.	50% Benzole.	75% Benzole.	Benzole.
Drop	83	77	76	75	77
5% over at	95	85	82	81	80
10% „	98	88	84	82	82
20% „	104	92	87	85	84
30% „	110	96	89	86	85
40% „	115	101	92	88	86
50% „	121	107	95	89	86
60% „	128	115	100	91	87
70% „	137	124	109	95	89
80% „	145	137	123	103	92
90% „	161	152	144	124	101
95% „	(174)	165	159	147	113
Dry „	187	182	180	175	160

It will be noticed that both in drop temperatures and flash-points the bulk of the lowering occurs with the first 25 per cent addition.

The amount of literature on the subject of the flash-points of any but petroleum products appears to be very small, and a few random references may be discussed here.

The figures given by Holde on petrol fractions have already been given. If we take his boiling ranges as giving the initial boiling-point of the sample we find the following results :—

B.P. Range.	Observed Flash.	Calc. Flash.
50–60° C.	−58° C.	−35
60–78° C.	−39° C.	−28
70–88° C.	−45° C.	−20
88–100° C.	−22° C.	− 8
100–115° C.	10° C.	+ 1

It is not easy to understand the last figure given unless —10° C. is meant, but no doubt the discrepancies in the other cases arise from the fact that on redistillation a drop-point considerably lower than the figure given would have been found.

The following values are also given :—

Alcohol Per cent.	Flash. Holde.	Present Work.
100	12	11
94	18	15½
70	22	(22½)
50	26½	—

Benzol is given as —8° C. at 710 mm. pressure which appears to be rather a high figure unless it contained some 50 per cent of toluene. Sherman, Gray, and Hammerslag (*J. Ind. Eng. Chem.*, 1909, 1, 13) give flash-points of mixtures of oils, but unfortunately, like many other observers, give no drop-points. They show that a flash-point of a binary mixture cannot be calculated by simple proportion from those of the two constituents. This, of course, follows at once from this work on vapour pressure considerations.

Dvorkovitz (*Pet. Rev.*, 1905, 13, 7, and 24) made an investigation into the flash-point of various fractions from kerosenes. He gives the "boiling-point" and flash of various kerosenes. It is evident, however, that the boiling-point given refers to the first drop obtained, using some kind of fractionating apparatus so that the results are not comparable with ours. The figures may be of interest, however.

	B.P.	Flash observed.	Flash calc.
Royal Daylight .	112° C.	26½° C.	10° C.
Amer. Water White	125° C.	42° C.	20° C.
Russian . .	130° C.	31½° C.	23° C.
Galician . .	110° C.	27½° C.	8° C.
Texas . . .	120° C.	30° C.	16° C.
Roumanian . .	112° C.	26° C.	10° C.

In a recent paper by Fred. H. Garner on the carbonisation of lubricating oils (J. VII, 26, 99, 1921) it is suggested that "The flash-point of an oil is probably related to its initial boiling-point or to the distilling range of the initial fractions. . . . It would seem that the flash-point, at least in the case of adjacent fractions of the same crude petroleum, depends on the temperature at which a definite vapour

pressure is attained, and at this pressure the requisite concentration of vapour in air is formed to produce an explosive mixture."

In the paper are given some results of the distillation (under 4 mm. pressure) and the flash-points of various fractions of Texas and Pennsylvania crudes. In order to calculate the flash-points from the distillation figures certain assumptions have to be made with regard to the vapour pressure curves of these oils. The distilling curves are also very steep so that flash-points would be too low as calculated from the drop-point. By graphical interpolation, however, we have determined the temperature at which 1 per cent had distilled over and have calculated the flash-points from these. The results are given in the following table where the oils are arranged in ascending order of drop temperatures.

Drop temp.	1% over.	Flash observed.	Flash calc.	Diff.
50° C.	84° C.	100° C.	105° C.	+ 5° C.
88° C.	102° C.	155° C.	124° C.	−31° C.
102° C.	116° C.	163° C.	139° C.	−24° C.
112° C.	132° C.	168° C.	156° C.	−12° C.
114° C.	126° C.	174° C.	149° C.	−25° C.
169° C.	185° C.	210° C.	212° C.	+ 2° C.
180° C.	188° C.	213° C.	215° C.	+ 2° C.
195° C.	203° C.	223° C.	231° C.	+ 8° C.
200° C.	232° C.	277° C.	262° C.	−15° C.
234° C.	260° C.	315° C.	292° C.	−23° C.

The agreement between the calculated and observed flash-points is not perhaps very striking, but the special circumstance of the case must be taken into consideration. In any case the fact may be noted that the observed flash-points are in the same order as the observed drop-points.

In the last table, as has been stated, it was necessary to make certain assumptions regarding the vapour pressure curves of the oils. It is now necessary to consider this question of the vapour pressure relations of liquids. It has been found that for any pair of non-associated liquids the following relation is approximately true :—

$$\frac{T_A^1}{T_B^1}=\frac{T_A}{T_B}=\text{constant (Ramsay and Young's Law).}$$

Where T_A+T_B are the boiling-points on the absolute scale of the two liquids under a pressure p, and $T_A^1+T_B^1$ their boiling-points under another pressure p^1. It follows, therefore, that taking the boiling-

point as unit temperature a standard vapour pressure curve can be constructed which will fit all other hydrocarbons. This rule was applied in calculating from Garner's results as above, using octane as a standard liquid.

While this simple law is not quite exact it holds near enough for the present discussion. It follows from the above law that at any particular fraction of the absolute boiling-point all such liquids possess the same vapour tension. The following figures taken by graphical interpolation from the work of Young, Ramsay, and others show this :—

PRESSURES IN MM. MERCURY.

	Hexane.	Heptane.	Octane.	Benzene.	Toluene.	Naphthalene.
B.P. °K	342	371	400	353	383	491
Vap. press.	760	760	760	760	760	760
·9×B.P. °K	308	334	360	318	345	442
Vap. press.	230	220	225	225	220	220
·8×B.P. °K	274	297	320	282	306	393
Vap. press.	48	42	42	44	44	43
·736×B.P. °K	252	273	294	260	282	361
Vap. press.	14·9	11·5	11·2	12·0	12·3	11·8

Reverting to the rule for flash-points it will be seen that it is precisely a factor of this type which we are using in the equation.

Flash-point °K = ·736, boiling-point °K.

From this it follows, therefore, that :—

At the flash-point all hydrocarbons possess (approximately) the same vapour tension.

At atmospheric pressure this vapour tension appears to be about 12 mm. for the lower flash and 40–50 mm. for the upper flash.

There would thus appear to have been a good deal of justification for the Salleron-Urbain type of flash-point meter (Redwood, *Handbook of Petroleum*) in which the vapour pressure of a kerosene in contact with water was used as a measure of its inflammability. The results appear to have been disputed by Engler and others, and the instrument has dropped out of use. It was suggested that liquids showing a pressure of not more than 64 mm. (of water) at 35° C. should be passed as "safe." If the whole of this pressure were due to the liquid being tested it would only amount to a vapour pressure of 5 mm. of

mercury and that at 95° F. As it would appear from the present work that the British regulations call for the vapour pressure to be below 12 mm. at 73° F. the Salleron-Urbain test would undoubtedly be much more stringent, and perhaps in the case of kerosene containing dissolved inflammable gas, a much better test than the Abel.

The following vapour tensions have been extracted from published curves for the observed flash temperatures :—

Sample.	Vap. press. at lower flash. mm. Hg.	Vap. press. at upper flash. mm. Hg.
Benzene	12·0	45
Toluene	12·8	38
Xylene	11·0	33
Naphthalene	10·6	—
Hexane	9·8	48
Heptane	11·4	31
Alcohols—		
Methyl	27·6*	162
Ethyl	25·6	82
m-Propyl	19·7	67
m-Butyl	16·9	—
Amyl	13·5	—
Ether	(18)	(45)

The values given for the bodies on page 23 may also be compared.

It is obvious that from the above figures we can calculate the explosive limit compositions of mixtures of these vapours with air, assuming Dalton's Law of Partial Pressures to hold.

Substance.	Per cent by vol. of combustible vapour in mixture Minimum.	Optimum (calc.).	Maximum.
Methyl Alcohol	3·6	10·8	21·1
Ethyl „	3·4	6·2	10·6
Propyl „	2·6	4·4	8·2
Butyl „	2·2	3·4	—
Amyl „	1·8	2·7	—

* Taking 12 mm. as the normal figure for an unassociated liquid, those for methyl and ethyl alcohol are 2·3 and 2·1 times higher.

The degree of association of these bodies at the flash temp. is, according to W. C. Mc. C. Lewis, 2·4 and 1·6 respectively.

Substance.	Per cent by vol. of combustible vapour in mixture. Minimum.	Optimum (calc.).	Maximum.
Benzene	1·6	2·6	5·8
Toluene	1·7	2·2	4·9
Xylol	1·4	1·9	4·2
Naphthalene	1·4	1·7	—
Hexane	1·3	2·1	6·5
Heptane	1·5	1·8	4·0
Ether	2·4	3·4	6·0

The above are all the values we feel justified in giving, it being felt that vapour tension measurements should be made on the samples we are actually using. We hope to take up this work in the near future, not only on pure bodies but also on petrols. The above results may be compared with those found by Eitner (*Explosionsgrenze Brennbaren Gase*, 1902) who determined the limits of inflammability of various vapours in a Bunte burette with electrical ignition and in a glass cylinder of 62 mm. diameter, using flame ignition. The results were as follows, only the lower values being given :—

	Per cent of combustible vapour by volume in mixture. Burette.	Cylinder.	Present work.
Alcohol . .	3·9	3·9	3·4
Ether . .	2·6	1·6	2·4
Pentane . .	2·2	1·3	1·6 (calc.).
Benzine . .	2·4	1·1	1·4 (mean hex-hep.).
Benzol . .	2·4	1·4	1·6

For the upper limits the following values were found in the Bunte burette (of 19 mm. diam.) :—

	Eitner.	Present Work.
Alcohol . . .	13·7*	10·6
Ether . . .	7·7	6·0
Pentane . .	4·9	5·3 (calc.).
Benzine . .	4·9	5·2 (mean hex-hep.).
Benzol . . .	6·5	5·9

* Eitner's work was done with an alcohol of ·8088 S.G. 15/15.

Following Eitner's example we can, of course, calculate the flame temperatures from the composition of the mixtures. Eitner's results are given under, being calculated, using Mallard and Le Chaterlier's value for the mean specific heats of the combustion products and somewhat hypothetical corrections for loss by radiation, convection, conduction, and dissociation :—

At lower flash.	Eitner.	Eitner recalculated.
Alcohol . .	1290° C.	1330° C.
Ether . .	960° C.	940° C.
Benzol . .	1310° C.	1310° C.
Pentane .	1250° C.	1270° C.
Benzine .	1400° C.	1450° C.

On the right we have put the temperature as calculated from Eitner's own data for the heat of combustion and composition of the mixture, but using a mean figure of 0·36 for the heat capacity per litre of the products of combustion. It will be seen that the difference is not serious, especially when the uncertainty of the specific heat determinations is considered.

Calculating flame temperatures from our own results in a similar manner, but using a mean figure of 0·37 for the heat capacity of the products of combustion (this being more in line with the recent specific heat work of Pier and Bjerrum (*Zeit. f. Elektrochemie*, 17, 731 (1911), 18, 101 (1912); *Zeit. Phys. Chem.*, 70, 513 (1912)), the following figures are obtained to the nearest 50° C. :—

		Eitner.
Methyl Alcohol	800° C.	—
Ethyl „	1400° C.	1290° C.
Ether . .	1600° C.	960° C.
Benzene .	1500° C.	1310° C.
Toluene .	1900° C.	—
Xylol . .	1850° C.	—
Naphthalene .	2700° C.	—
Hexane .	1550° C.	1450° C. (Benzine.)
Heptane .	2050° C.	

It is, of course, not pretended that the above figures are exact; an error of, say, 30 per cent would be not matter for surprise. The out-

standing high value for naphthalene will be noticed. This is borne out by the extremely brilliant light which is given by the electric spark in naphthalene vapour.

The application of the foregoing results to the internal combustion engine is not difficult if we treat it in an approximate manner only. It will be obvious, of course, that a liquid having a low flash-point should give very much easier starting than one which has a higher flash-point. Should the flash-point be too low the mixture will be too rich to start, but this is not a danger which need be apprehended with any normal fuel under normal conditions. From the figures given for the upper and lower flash-points and the composition of the explosive mixtures worked out therefrom some idea of the explosive range of the various fuels can be obtained. It is evident that with the alcohols, particularly ethyl and methyl, a very much greater range of fuel-air ratio is permissible than with the hydrocarbons. Thus we find that whereas ethyl alcohol-air mixtures will ignite when there is 3·4 per cent of alcohol present up to 10·6 per cent, in the case of all the hydrocarbons the range appears to be from something like 1½ per cent up to 4½ per cent.

In the cylinder of the engine the conditions obtaining, of course, are different from those in the flash-point meter in that the pressure is enormously increased by an amount dependent on the compression ratio of the engine. In an engine cranked by hand we will take as a first approximation that the P.V. relationship follows Boyle's law, there being time for a good deal of the heat developed to pass into the cold engine. On this assumption we are able to calculate at what temperature of carburation the mixture in an engine with a given compression ratio will cease to ignite. The figures so calculated for benzol and for petrol are as follows :—

	Minimum carburettor temp.	
Compression.	Benzol (drop 80°).	Petrol (drop 60°).
1 atmos.	−13	−28
2 „	+ 5	−11
3 „	16	− 1
4 „	26	+ 9
5 „	33	16

It will be noticed that at a compression of 3 to 1 this temperature for benzol is about 16° C., that is to say, the average temperature of the air, whereas for an ordinary petrol the temperature is −1, thus giving a hint as to the very much easier starting obtained with petrol than with benzol. At 5 to 1 compression the minimum carburation pressure

for benzol is well above the ordinary atmospheric temperature, while with petrol it has only just reached the latter figure.

It is probable that the above assumption in regard to the P.V. relationship is only very approximately true. When running at full speed the relationship approximates more nearly to the adiabatic equation for an ideal gas for which the constant is about 1·41. It is possible, therefore, that in calculating the above results we should have taken an index of say 1·1 or 1·2, but as this appears to be a very uncertain matter we have not thought it worth while to carry out the calculations. There are some other aspects of the matter which are hardly worth while committing to paper, but which will probably arise in the discussion and may therefore be left until that period.

In this research we have dealt with a large number of bodies in a somewhat superficial manner as was necessary in seeking for a general law. Having arrived at an inkling of this general law it now remains to establish the case of each body in such a manner that it cannot be questioned. This means the purification of each body to the very last degree and determination of the boiling-point and flash-point, using more refined methods and thermometry. In spite of various defects, of which we are aware, it is hoped that this paper will be of real value, both from the theoretical and from the practical standpoint.

Our thanks are due to Mr. E. Connolly for his ready help in connection with this work.

This work may be regarded as one portion of the extended investigation which is being carried out on the physical properties of pure and mixed fuels at the joint request of the Distillers' Co., Ltd., and the Fuel Research Board of the Department of Scientific and Industrial Research. We wish to take this opportunity of recognising the financial assistance rendered by them towards the expenses of this research.

APPENDIX A.

Notes on Character of Liquids Employed in the Work.

We are indebted for many of the special petrols, paraffins, etc., to the Distillers' Company, Ltd., to Mr. Kewley and Mr. Marshall of the Asiatic Petroleum Company, and to Mr. Ricardo. The origin of other bodies is given below.

All S.G.'s are at 15/15° C. unless otherwise stated.

KEROSENES.

	American.	Mex.	Borneo.	Edeleanu extract.
Specific Gravity .	·801	·784	·853	0·899
Engler Distillation :—				
	American (1).	Mex. (1).	Borneo.	Extract.
Drop ° C. . .	165	140	148	170
5% over @ ° C. .	180	151	165	180
10% „ .	185	156	171	182
20% „ .	200	166	181	192
30% „ .	210	175	191	197
40% „ .	217	183	202	205
50% „ .	226	193	213	213
60% „ .	235	202	224	221
70% „ .	246	211	236	232
80% „ .	257	226	249	245
90% „ .	279	249	264	259
95% „ .	299	269	282	—
Dry „ .	315	290	306	300

PETROLS.

	Pratts (2)	Red Line	Shell
Specific Gravity . . .	·722	·720	·756
Distillation :—			
Drop ° C. . . .	55	58	63
5% over @ ° C. . .	73	76	83
10% „ . .	78	82	90
20% „ . .	80	90	97
30% „ . .	95	98	104
40% „ . .	102	105	109
50% „ . .	110	113	115
60% „ . .	120	121	123
70% „ . .	130	130	131
80% „ . .	146	145	138
90% „ . .	164	159	156
95% „ . .	188	176	169
Dry „ . .	193	180	180

RICARDO PETROLS.

	A	B	E	F	H
Specific Gravity . .	·783	·724	·722	·716	·744
Distillation :—					
Drop	84	50	57	57	92
Over @ 60° C. per cent.	—	4	2	1	—
„ 80 „	—	36	16	26	—
„ 100 „	14	77	42	66	6
„ 120 „	57	93	67	86	48
„ 140 „	84	—	84	94	78
„ 160 „	96	—	92	—	90
„ 180 „	—	—	—	—	96
Dry	169	128	179	154	198

AROMATICS.

Benzene.—As used in solubility work.

S.G. 0·8832. M.P. 5·2° C.
Distils 79·0–81·0° C.*

Toluene.—

S.G. 0·8879.
Distils 109·0–111·7° C.

Xylol.—As bought.

S.G. 0·8665.
Distils 138–148° C.

Amyl Benzene.—For this sample we are indebted to Mr. Radcliffe.

S.G. 874.
Distils 195–224° C.

HYDRO AROMATICS, NAPHTHENES, ETC.

Cyclo hexane . . .	S.G. ·781	Distils	79–88
Methyl cyclo hexane (H.H.T.)	„ ·775	„	95–103
Hexa hydro xylene . .	„ ·745	„	118–123
Tetraline (crude) . .	„	„	132–230

ALCOHOLS.

Methyl Alcohol.—A redistilled sample of "0·1 per cent acetone" quality was used.

S.G. 0·797.
Distils 64–67° C.

* Engler drop to dry point in each case.

Ethyl Alcohol.—"Absolute" from dealers and 95 per cent vol. from the Distillers Co., Ltd.

The S.G. of the strong used was ·796.
Distils 78– ° C.

Propyl Alcohol.—From the U.S. Ind. Chem. Co. After 3 fractionations through an 8-bulb column, drying with K_2CO_3 between, a small middle fraction was separated, coming over between 96½° C. and 98½°.

S.G. 0·811.
Distils 95–100° C.

Butyl Alcohol.—From the Synthetic Products Co. After drying with K_2CO_3 gave after two fractionations a large middle fraction coming over constant at 117½° C.

S.G. 0·804.
Distils 116–18.

Amyl Alcohol.—Commercial "fusel oil" distilling 122–138° C. was fractionated twice through a special column of 6-section and a fraction distilling 129–32 collected.

S.G. 0·818.
Distils 128–132.

This would appear to indicate a very large proportion of the iso-alcohol.

Paraffins.

Hexane.—Several samples of mineral origin were fractionated several times and a middle fraction collected.

S.G. 0·689.
Distils 64–71° C.

Heptane.—From *Pinus sabiniana.* Washed several times with sulphuric acid raising anilin point from 69·5 to 70·1° C. Three fractionations through an "Evaporator" Still head of 8 sections gave a 90 per cent middle fraction passing over 98·3–98·4° C.

S.G. 0·689.
Distils 98–99° C.
Anilin point 71° C.

A second sample reputed to be of mineral origin gave results very similar to the above which seems to throw some doubt as to the origin.

Miscellaneous.

Ether.—A sample of "undenatured" ether was used.
S.G. ·724.
Distils 34·2–45° C.

Bone Oil.—
S.G. 0·930.
Distils 125–235 (90 per cent over).

Caoutchoucine.—
S.G. 0·875.
Distils 109–255 (90 per cent over).

Acetone.—As bought.
S.G. 0·800.
Distils 50–60° C.

APPENDIX B

Comparison of Flash and Drop Temperatures of Heavy Oils.

Most of the following figures have been supplied by Mr. Harold Moore, who adds the following note, "Water affects both closed flash-point and also the Engler test as it raises flash by damping and causes lowering of 'drop' in distillation by steam distillation. The effect is undoubtedly very great."

Sample.	Closed Flash (Gray).	Drop.	R =
Gas Oil Galician . . .	63° C.	160	·776
" " . . .	71° C.	172	·773
Residue	82° C.	194	·760
"	74½° C.	136	·850
Gas Oil	72° C.	168	·782
"	99½° C.	232	·739
"	83° C.	149	·844
B.F. Tar Distillate . .	80° C.	137	·861
Paraffin "Homelight" .	28° C.	150	712
"Petrolite" . . .	40° C.	137	·764
Broxburn Oil . . .	30° C.	140	734
Digboi Fuel Oil . . .	66° C.	215	·694
Anglo-Persian . . .	93° C.	225	·735
Chile	46° C.	185	·699
Horiz. R. Tar Oil . .	93° C.	190	·761
Vert. R. Tar Oil . . .	88° C.	120	·918
Blast Furnace Tar . .	35° C.	185	·673

DISCUSSION.

The President, in opening the discussion, said that Dr. Ormandy was to be congratulated on the work which he had brought before the Institution that evening, and on the very admirable manner in which he had presented it. The question of flash-points, of course, was a very old one. One thing which had struck him in connexion with the comparison which Dr. Ormandy had given was that, in spite of the somewhat crude form of the ordinary flash-point apparatus, the results were on the whole in quite good agreement with the results which had been obtained with Dr. Ormandy's more scientific piece of apparatus. It was only when liquids had a very mixed composition that there appeared to be any very great difference; with practically pure liquids the difference was only a matter of a degree or two, so that although the ordinary flash-point apparatus was a purely commercial instrument it appeared to be fairly well adapted for ordinary laboratory use.

Another point was the connexion between initial boiling point and first drop temperatures. He realised that it was a very difficult matter to get the initial boiling point of many of the liquids, especially those having a mixed composition. In carrying out a large number of comparative tests with various forms of fractionating apparatus dealing with petrol, he had found that the determination of the first drop temperature was a very uncertain matter—that it depended very largely upon the type of apparatus used, and that the quantity of liquid used also had a very considerable influence on the result. That was to be expected, especially in cases of somewhat abnormal liquids; for instance, a special type of petrol where the lighter constituents had been mainly removed, and were but little distilled until temperatures of 70 or 80° C. were reached. Some special aviation spirits were of that character. There the first drop temperature—which, he understood, Dr. Ormandy regarded as the initial boiling-point—was a very variable thing. Even with ordinary everyday aviation spirits, using 5-bulb Young dephlegmators, temperatures of 25 or 30 degrees were obtained for first drop temperatures; but when the Engler method was used temperatures as high as 40 and 41 deg. and even higher, were recorded; so that he thought that Dr. Ormandy's results, valuable as they were, would have received even greater confirmation if it had been possible for him to adopt some method for determining those initial boiling-point temperatures with a greater degree of accuracy.

The first drop temperature by the ordinary Engler method was too erratic without using at least 200 cubic centimetres. There was not enough vapour condensed to give the first drop until the thermometer had risen for some considerable distance above the

Miscellaneous.

Ether.—A sample of "undenatured" ether was used.
S.G. ·724.
Distils 34·2–45° C.

Bone Oil.—
S.G. 0·930.
Distils 125–235 (90 per cent over).

Caoutchoucine.—
S.G. 0·875.
Distils 109–255 (90 per cent over).

Acetone.—As bought.
S.G. 0·800.
Distils 50–60° C.

APPENDIX B

Comparison of Flash and Drop Temperatures of Heavy Oils.

Most of the following figures have been supplied by Mr. Harold Moore, who adds the following note, "Water affects both closed flash-point and also the Engler test as it raises flash by damping and causes lowering of 'drop' in distillation by steam distillation. The effect is undoubtedly very great."

Sample.	Closed Flash (Gray).	Drop.	R =
Gas Oil Galician . . .	63° C.	160	·776
" " . . .	71° C.	172	·773
Residue	82° C.	194	·760
"	74½° C.	136	·850
Gas Oil	72° C.	168	·782
"	99½° C.	232	·739
"	83° C.	149	·844
B.F. Tar Distillate . .	80° C.	137	·861
Paraffin "Homelight" .	28° C.	150	712
"Petrolite" . . .	40° C.	137	·764
Broxburn Oil . . .	30° C.	140	734
Digboi Fuel Oil . . .	66° C.	215	·694
Anglo-Persian . . .	93° C.	225	·735
Chile	46° C.	185	·699
Horiz. R. Tar Oil . .	93° C.	190	·761
Vert. R. Tar Oil . . .	88° C.	120	·918
Blast Furnace Tar . .	35° C.	185	·673

DISCUSSION.

The President, in opening the discussion, said that Dr. Ormandy was to be congratulated on the work which he had brought before the Institution that evening, and on the very admirable manner in which he had presented it. The question of flash-points, of course, was a very old one. One thing which had struck him in connexion with the comparison which Dr. Ormandy had given was that, in spite of the somewhat crude form of the ordinary flash-point apparatus, the results were on the whole in quite good agreement with the results which had been obtained with Dr. Ormandy's more scientific piece of apparatus. It was only when liquids had a very mixed composition that there appeared to be any very great difference; with practically pure liquids the difference was only a matter of a degree or two, so that although the ordinary flash-point apparatus was a purely commercial instrument it appeared to be fairly well adapted for ordinary laboratory use.

Another point was the connexion between initial boiling point and first drop temperatures. He realised that it was a very difficult matter to get the initial boiling point of many of the liquids, especially those having a mixed composition. In carrying out a large number of comparative tests with various forms of fractionating apparatus dealing with petrol, he had found that the determination of the first drop temperature was a very uncertain matter—that it depended very largely upon the type of apparatus used, and that the quantity of liquid used also had a very considerable influence on the result. That was to be expected, especially in cases of somewhat abnormal liquids; for instance, a special type of petrol where the lighter constituents had been mainly removed, and were but little distilled until temperatures of 70 or 80° C. were reached. Some special aviation spirits were of that character. There the first drop temperature—which, he understood, Dr. Ormandy regarded as the initial boiling-point—was a very variable thing. Even with ordinary everyday aviation spirits, using 5-bulb Young dephlegmators, temperatures of 25 or 30 degrees were obtained for first drop temperatures; but when the Engler method was used temperatures as high as 40 and 41 deg. and even higher, were recorded; so that he thought that Dr. Ormandy's results, valuable as they were, would have received even greater confirmation if it had been possible for him to adopt some method for determining those initial boiling-point temperatures with a greater degree of accuracy.

The first drop temperature by the ordinary Engler method was too erratic without using at least 200 cubic centimetres. There was not enough vapour condensed to give the first drop until the thermometer had risen for some considerable distance above the

initial boiling-point. The necessity for taking into consideration the time factor was also of importance.

The only other point to which he desired to refer was the important question of the dissolved gas in petrols and kerosenes. Mr Harold Moore, in determining the vapour pressure of some liquids, found that they often contained a good deal of dissolved gas, which had a great influence on the vapour pressure. He (the President) had had a similar experience, and it was not by any means due, as some had assumed, always to air, but there were dissolved hydrocarbon gases, which Dr. Ormandy had encountered. He hoped that Mr. Moore would be able to say something in that connexion. Before throwing the discussion open he would ask Dr. Ormandy's colleague, Mr. Craven, if there were any points which he would like to add to the description which Dr. Ormandy had given.

Mr. E. C. Craven said that dealing first with the apparatus itself and the arrangement for evaporating liquid SO_2, those of the members who had seen the arrangement which had been used for the solubility of the aromatic hydrocarbons in alcohol would know that Dr. Ormandy and himself had used two glass tubes coming through the rubber stopper for leading in the liquid SO_2 and for attaching the vacuum pump. That was done for the reason that these tubes became cooled down and the moisture of the air condensed on them; there was a precipitation of frost, and some of that was liable to get into the inner test tube if one was not careful. In the present form they took in the liquid SO_2 below the mouth of the inner tube and therefore it could not enter. On the other hand, they got the defect that there was no point at the bottom of the tube from which boiling could take place, and one did not get such steady ebullition. Dr. Ormandy had not referred to the work which they had done on heptane and variation of flash-point with pressure. They had carried out the flash-points of heptane down to a pressure of about one-third of an atmosphere, and they found the results were in substantial agreement with the law which they had formulated; the constant came out at about ·725 instead of ·736.

With regard to the question of dissolved gases in hydrocarbons, those who had done vapour tensions would know that that was a very real bother indeed. As an example he would like to refer to what he had been told by a man with some forty years' experience in the distilling of naphtha. They were at that time trying various methods of washing crude naphtha, and, before applying the sulphuric acid test for the efficiency of the washing to the distilled fractions, he had been informed that it was necessary to steam distil the naphtha and not to do it by the naked flame. He found that that chemist could tell from a dozen samples put before him which had been distilled by the naked flame and which had been done by steam. Those which had been distilled by the naked flame

over a gauze or a plate had a burnt smell, and that was evidence that a considerable amount of cracking did go on even at temperatures as low as the boiling-point of benzene and toluene, say 80 deg. up to 120° C. That cracking brought about the formation of gas which dissolved in the hydrocarbons, which passed over and gave it the smell which could be detected.

The President had mentioned that perhaps Dr. Ormandy and he would have done better to have used efficient fractionation in doing the drop temperature of liquids. Their idea in doing the distillation test was rather to come as near as possible to the conditions which obtained in the flash-point meter itself. There they had practically no fractionation whatever, and their idea really was to carry out the distillation under those conditions with as little fractionation as possible, and in his humble opinion—not that he would set it up against Prof. Brame's—they would have done far better to have lagged the Engler distillation flask rather than attach any form of dephlegmating apparatus whatsoever.

Mr. Moore said that when making determinations of the vapour pressure of petrol and benzol (more especially of petrol) some two years ago, he had encountered the gases in solution in these fuels. There was little doubt that the gases were inflammable, and their presence raised the question of whether the gas is to be considered as a portion of the sample to be tested, or was it to be considered as an impurity which should be removed prior to testing the sample. He had taken the former view, namely, that the substance present in the tin was the sample, and should be tested as it was received. Morton had made a vapour tension apparatus and had extracted the gases most carefully. Their presence greatly affected the result. He, Mr. Moore, would have liked to have seen some further examples of the flash points of binary mixtures. Of course these flash points depended on vapour tension, and the vapour tension of mixed substances, if the substances were insoluble in each other, was equal to the sum of the vapour tensions of the two components of the mixture. In practice, with soluble mixtures, the vapour tension of the mixture was often greater than that of either individual constituent, but always less than the sum of the two. It should follow that many of these mixtures should have a lower flash point than that of either component. Unfortunately the examples given were not such as to demonstrate this. As benzol is generally present in commercial petrol it exercises an effect on the flash point of the petrol, thus interfering with the obtaining of a true benzol-petrol mixture curve. With mixtures of alcohol and petrol, which were not so easily soluble as benzol and petrol, the vapour tension curve reached a maximum, from which it may be assumed that the flash-point curve should give a minimum. He did not see the necessity for Dr. Ormandy's explanation of the exceptional

flash point of methyl alcohol being due to the degree of association. Was it not a function of the lower limit of flame propagation? It was known that with these products of high oxygen content, such as methyl alcohol, and also with substances containing large quantities of chlorine or nitrogen, a larger amount of substance was necessary, mixed with air, to give an inflammable mixture. In the case of methyl alcohol a good deal more air was required to form an explosive mixture than with ethyl alcohol.

Dr. R. Lessing said the last point mentioned by Mr. Moore had also occurred to him, and he had been going to ask Dr. Ormandy whether the apparatus could possibly be adapted for varying the ratio of liquid space to air space above it. It seemed to him that that should be possible either by raising the thermometer with its shield or by possibly lengthening the shield. That would, in the first instance, give further opportunity of comparing that new apparatus with the existing ones, and possibly lay down more clearly the lines on which the apparatus should be constructed in the future, or it might point out the defects of the existing ones, which, as had already been said, were, after all, comparatively small. It would therefore allow—if that was desired, although he supposed for standard conditions it would not be desirable—for varying the conditions for different classes of substances. That ratio of air or vapour space above the liquid space was also the one which he believed largely influenced the accuracy or otherwise, or the agreement, of the determinations of drop temperature in Engler distillation or in any distillation. He believed it was the common experience of all those who had to do a great many distillations that the first drop in hydrocarbons at any rate, and even in alcohols, was always milky—always turbid—and therefore afforded a clear indication that it had something to do either with the moisture present in the liquid or with the moisture in the air above the liquid, which therefore played the part of the steam in steam distillation. He believed that that was a very important point. In a great number of distillations which he had had occasion to carry out on pure benzene and toluene and also on pure petroleum hydrocarbons, he had found that he obtained a considerable quantity in all cases of the lower boiling material in a turbid condition before the main distillate appeared. He put it down, in part at least, to the fact of moisture being present in the air space above the liquid, and possibly also, where fractionating columns were used, on the walls of the fractionating columns or in the structure of them. He referred particularly to columns filled with contact rings, which offered a very great surface for water to condense before distillation started. It would be interesting if conditions could be devised by which, in the case of pure substances, the first fraction could be eliminated and the work done on the residue; in other words,

if the apparatus could be converted into a retort or still from which a certain fraction, say down to the 7 c.c. which were required, would be distilled off without allowing access of air.

Dr. Ormandy said that that had been done.

Dr. Lessing said he thought that should give possibly a means of excluding the lower boiling fraction. He noticed that the authors had gone through that same experience of finding that it took up a very considerable amount of fractionation and re-fractionation to free liquids of those low-boiling constituents which, in the end, determined the flash point. Not only was it a question of removing the liquid but it was also a question, in successive fractionations, of avoiding the re-contamination of the residue of the purer material with moisture, or possibly even gases or mixture with air.

Dr. Thole agreed with the President that the temperature at which the first drop is obtained on distilling 100 c.c. of a complex mixture such as petrol or kerosene, is by no means an indication of the true boiling point of the hydrocarbons present in this drop. The first 1 per cent. of a kerosene with initial boiling point 140° C. by Engler test usually boils below 100° C. on redistillation.

The marked effect on the apparent flash point of varying the ratios of liquid and vapour spaces in the case of such mixtures finds a parallel in vapour tension experiments where the results are greatly influenced by this consideration. Dissolved gases in particular affect these physical characteristics.

The speaker asked if the effect of increased pressure on flash point was constant for all liquids, or whether it was dependent on their chemical nature.

He considered that the visible moisture present in the first few drops of distillate from coal tar or petroleum hydrocarbons was derived mainly from the water dissolved in them, and only to a small degree from moisture on the interior surface of the flask. Benzol dissolves ·05 per cent. of water and petrol about one-tenth this quantity, and the relative turbidities visible on distillation are approximately in this proportion.

Mr. E. A. Evans pointed out that some connexion should exist between the temperature at which a substance will flash and its boiling point or vapour pressure has been anticipated by several workers, but it appears that the authors are the first to show definitely that some such connexion does really exist.

The actual factor, of course, is of small moment, because it is conceivable that it is based upon the method which is recognised at the moment for determining the initial boiling point of the substance under consideration. Although the work has been confined to substances with a flash point not exceeding that of the boiling point of water, there is probably no reason why it should

not apply to substances with a higher flash point. If the authors have not already commenced experiments on such substances I feel tempted to do so, because the method which is described in the paper for making the determination is one which appeals to me very strongly, for the very reasons which have been advanced in the paper.

It is stated that care should be taken to restrict the number of sparks passed to a minimum in order to avoid using up the oxygen present in the combustion space. Has it been established that a serious consumption of oxygen does really take place by the few sparks that would be used even if a spark were passed with every degree rise in temperature. To overcome the possibility of the combination of the nitrogen and oxygen under the influence of the sparking, it would be interesting to know whether the authors have tried igniting the vapour with the red hot filament.

The method for taking the low flash is very clearly described, but there does not appear to be any description of how the high flash should be taken. Perhaps we may have some guidance on this point.

Will the authors kindly state how the gas was removed from the oil, as this problem appears to have given some difficulty. I should have thought that it would have been a comparatively simple operation to pump off the gas by placing the oil in a Torricellian Vacuum. Perhaps this was the method which was finally adopted. Moore, when he carried out his work on vapour tensions, adopted this method with good results.

It is stated in the paper that a considerable amount of gas is soluble in the oil, in fact it is stated that the distillation loss may be as high as 20 per cent. Does this mean that there was 20 per cent. of gas present? In the case of Hexane the flash point was raised from $-31\frac{1}{2}^\circ$ to -26°, but there is no indication as to the amount of gas which was extracted. May we assume that it was at least 5 per cent. and that the removal of 5 per cent. would account for a rise of $5\frac{1}{2}^\circ$ in the flash point. As this immediately follows upon the statement that 5 per cent. loss was obtained in the case of Pentane, I fear that this cannot be so, because in the case of American Kerosene, which only contained 0·1 per cent., gave a difference in flash of 11°.

Dr. Ormandy, in reply, said the President in his opening remarks had referred, as he had fully expected, to the question of the determination of the first drop temperature. It was, he thought, perfectly obvious that as the factor was a ratio in which the boiling-point was one end of it, it followed that whatever means were employed for determining the first drop temperature would only affect the nature of the constant. It might be ·736 or it might be ·732 or something else, according as one altered the conditions which one laid down as being the conditions for obtaining the first

drop temperature. The Engler conditions as specified by the American Bureau of Standards, which were generally accepted elsewhere, were more or less known, and if carried out strictly according to the instructions they gave figures which were reasonably in agreement. They were pretty closely the same if carried out by two or three different people, so long as they stuck to the conditions laid down. As it took several degrees difference in the boiling-point to make a difference of ·01 in the constant, it was quite clear that some point had to be fixed, and it was better, he thought, to take the best known and simplest method of determining the first drop temperature. Obviously the correct factor is the one which will be obtainable from a pure liquid, since here the first drop temperature corresponds to the real boiling point, and this figure is ·736. It was quite obvious that if one had a liquid where in 100 c.c. one had only got a very small amount of volatile, not enought to make a drop at the boiling point of the volatile liquid, it would be seen, when that liquid came into the instrument where there were 7 c.c. only, that one was not going to have enough of that volatile material to saturate the air inside the instrument so as to give an explosive mixture, and therefore the flash point would, of necessity, require that the boiling-point temperature should be higher; and in a sense those things corrected one another. The vapour pressure determinations might also be used as a means for calculating the flash point, but unfortunately vapour tension determinations were much more difficult to do. The errors in them were very much greater due to the presence of those dissolved gases, and in discussing that Mr. Craven and himself had come to the conclusion that the only way in which they were likely to get vapour pressures which could be brought into line for accuracy, even with the despised Engler first drop temperature, was to determine the boiling-points of those liquids under various pressures and plot them as curves; in other words, to do an Engler distillation under various conditions of vacuum and to plot them all out as curves and then take an isobar through the first drop portion of the curve, and from that get the vapour pressures.

Mr. Moore referred to the effect of gas in vapour pressure and the fact that he regarded it as being part of the substance, which was quite right looking at it from the point of view of its flash-point and its influence on the flash point from the user's point of view; that was to say, from the motorist's point of view. In the particular research under discussion the authors were looking at it from the more strictly scientific point of view, and they wanted to get rid of that very small amount of gas, which in actual weight was almost infinitesimal, but which yet had a very great effect, both on the flash point and still more on the vapour pressure determinations.

With regard to the work on mixed liquids, he thought they had chosen three or four types of mixtures which gave all the types of distillation curves; that was, those forming eutectics—if they might use the word "eutectic" for liquids—the boiling point of which was not the mean of its constituents, and those in which there was no action, and they referred in the paper to certain pairs of liquids which they were led to think would have very abnormal curves of vapour pressures and of ignition points. Those liquids they hoped to investigate, but the main difficulty was, of course, that of getting pure materials. They had determined benzol and petrol, and also alcohol and ether and alcohol and petrol.

Dr. Lessing suggested that they should be able to vary the ratio liquid air space. They had done that to a certain extent, and in connexion with the work on the influence of gases they were going further into that matter, because, by determining the flash-point of certain liquids with a large air bell or a small air bell, the ratio of the flash point as determined under the two conditions would, he thought, eventually be one of the safest and the most accurate methods for determining the amount of gas which was contained in the liquid. That was forecasted in the paper, and investigations were being carried out in that direction. With regard to distilling liquid and removing, as it were, the first drop or two which might be due to gases and cracked products, and then re-distilling it with a view to getting the first drop temperature, he thought Mr. Banks was actually engaged on that very investigation when he left the laboratory that day. It required to be done.

Dr. Thole also referred to the first drop temperature, and he had dealt with that point. He agreed with Dr. Thole entirely that the effect of those gases on vapour pressure determinations was exceedingly great, and the ratio of the amount of liquid which one used in the vacuum was a determining factor. For that reason he thought better results would be obtained by tackling the vapour pressure problem from another point, because, dealing with the boiling points, one could boil for a long period of time and eliminate the gas if it was going to be driven out at all by boiling. With regard to the other point raised by Dr. Lessing, about the milky nature of the first drop, he agreed with Dr. Thole that, although it was found to a very high degree in dealing with benzol and toluol and the aromatics, it was found to a very small degree when dealing with the naphthas and the petrols.

On the motion of **The President**, the thanks of the Institution were accorded to Dr. Ormandy and Mr. Craven for their very excellent paper.

The meeting then terminated.

The Systems Ethyl Alcohol—Water—Paraffins from +30° C. to −30° C.

By W. R. Ormandy and E. C. Craven.

The present paper is a portion of a research which is being carried out on the miscibility of petroleum products with aqueous alcohol. The work is being carried out over a wide range of alcohol concentration, and from +30° to −30° C. It has been found by experiment that no exact laws can be formulated for the solubility of such complex mixtures as petrol spirits. It has been thought better, therefore, to work on the pure constituents of such petroleum products and on artificially made mixtures thereof in order to arrive at a clear understanding of the exact effects of different types of constituents in regard to the alcohol solubilities.

Petroleum spirits are usually regarded as being made up of various members of the following series :—

(1) Paraffins. (2) Naphthenes.
(3) Aromatics. (4) Olefines.

For a list of the constituents which have isolated from or detected in petroleum spirits, reference may be made to Report No. 47 of the American National Advisory Committee for Aeronautics and to the usual textbooks. Analyses of various petrols will be found also in Ricardo's report on his recent compression tests, etc., which appeared in the *Automobile Engineer* for April, 1921. By the courtesy of the Anglo-Asiatic we have been able to procure various samples of products as used by Ricardo in his tests, including hexane and heptane. These are not chemically pure, but it was thought better at this stage of the work to examine the bodies as actually employed in the detonation compression tests, etc. in order to find what connexion, if any, there might be between the order of solubility and the constants determined by such tests.

There is a very great difficulty in obtaining samples of pure paraffins in this country, so that in all we have only to work on four bodies so far, namely :—pentane, isopentane, hexane and heptane. At a later date it is proposed to bring these bodies to a reasonable purity by fractional distillation, etc., but the present degree of purity is indicated by the figures shown on next page.

Substance.	SG 15/15	Drop.	5%	10%	20%	50%	80%	90%	Dry.	Loss.
Pentane 1	·6493	28·0°	28·7°	29·0°	29·8°	32·2°	46·6°	—	133° C.	14%
„ 2	·6308	31·6°	31·9°	32·1°	32·3°	33·3°	39·0°	43·6°	44° C.	6%
Isopentane	·6270	27·8°	28·1°	28·2°	28·4°	28·9°	34·2°	38·1°	41° C.	8%
Hexane 1	·6883	62·5°	64·5°	65·0°	65·9°	68·2°	71·7°	74·7°	85° C.	2%
„ 2	·6885	62°	64·8°	65·0°	65·7°	68·1°	71·9°	76·5°	85° C.	4%
„ 3	·6888	64·5°	66·0°	66·0°	66·6°	67·5°	68·8°	71·2°	74° C.	3%
Heptane 1	·6887	97·5°	98·4°	98·4°	98·5°	98·8°	99·2°	102°	108° C.	1%
„ 2	·6933	97·5°	98·4°	98·7°	99·0°	99·3°	100·7°	103·4°	118° C.	1%
„ 3	·7190	96·0°	96·8°	97·0°	97·5°	98·4°	99·8°	101°	104° C.	1%

Pentane 1 is Kahlbaum's "Refined" and Pentane 2 Kahlbaum's "Normal aus Petroleum." The isopentane was bought from the chemical dealers and is of unknown origin. Hexane 1, 2 and 3 are from the Asiatic Petroleum Company and are from petrol. Heptanes 1 and 2 are of vegetable origin, and with the hexanes are as used by Ricardo. Heptane 3 is from Germany and is said to be of mineral origin.

The following table gives the published values by several observers for the boiling point and specific gravity of the bodies mentioned. Where the Specific Gravities have been given at temperatures other than 15-15° C. they have been corrected to that temperature, using the observers' data wherever given, for the expansion or a mean figure otherwise :—

PENTANE.

S.G.	S.G. corrected to 15-15.	B.P.	Observer.
0·6337 15-15 ..	6337	36–36·5	Perkin, J. für prakt. chem. (2), 31, 488.
0·6454 0-4 ..	6310	36·3	Young, J.C.S. 71, 446.
0·6484 0-4 ..	6340	36·3	Timmermans, Bull. Soc. Chem. Belg. 1911.
		36·3	Thorpe Jones, J.C.S. 63, 274.
Mean ..	6329	36·3	

ISOPENTANE.

0·6282 13·7-4 ..	0·6275	30·5-31·5° C.	Schiff, A. 220, 87.
0·6387 0-4 }	0·6244	30·4° C.	Thorpe Jones, *loc. cit.*
0·6086 30·4-4 }			
0·6393 0-4 ..	0·6249	27·95° C.	Young & Thomas, J.C.S. 71, 540.
0·6393 0°-4 }	0·6251	27·9° C.	Biron Tables Annuelles Int., 1910.
0·6200 20-4 }			
	0·6250	27·9° C.	

HEXANE.

0·6681 10·8-4 ..	0·6641	69° C.	Zander, A° 214, 165.
		68·95	Young, "Fractional Distillation."
		68·6	Friedel Gorgen C. r. 127, 592.
0·6770 0-4 ..	·6640	—	Francis & Young.
0·6603 2034 ..	·6660	—	Brühl B. 27, 1106.
0·6739 15-15 ..	·6739	—	Perkin, *loc. cit.*
0·6721 20-4 ..	·6681	—	Tyrer (Tables Am. Int. 1910)
0·6872 0-4 }	·6744	69·0	Biron (Tables Am. Int. 1910)
0·6694 20-4 }			
Mean ..	·6684	68·9°	

HEPTANE.

·7085 0-4 ..	0·6969	98·0 100·5 98·4	Warren (aus Steinol). ,, (aus Azelainsaure). ,, (Pinus sabin).
·7006 0-4 ·6886 14·9-4 ·6840 20·5-4	·6890		Thorpe.
·7019 0-4 ..		98·2–98·5	Francis & Young, J.C.S. 73, 921.
·6885 15·15 ..	·6885		Perkin, *loc. cit.*
·6814 25·25 ..			
·6920 10-4 ..	·6884		Young, Sc. proc. R. Dub. Soc. (N.S.) 12, 446.
·6836 20-4 ..		98·4	
Mean ..	abt. 0·6885	98·4	

It will be seen that the samples as used for the alcohol solubility work show some differences from the values for the pure bodies. Taking the pentanes—Lot 1 is too high in S. G., probably owing to the higher boiling point products present. These bodies also contained a high percentage of gaseous or very low B. P. bodies, as was obvious from the high pressure developed in the containers, and as is shown by the large losses in distillation which far exceeds the loss noted in distilling a liquid of similar B. P. ether, for example. The samples of hexane appear to be high in S. G., probably owing to the presence of benzene or possibly polymethylene compounds, as found by Young in similar distillates from petroleum. Heptane of vegetable origin is commonly reputed of high purity, but that from petrol can never be thoroughly separated from isomers and other bodies.

The method of carrying out the solubility, etc. measurements is described in a paper entitled: "The systems benzene, alcohol, water from +30° C. to —30° C." (*Journal*, Dec., 1921).

The only alteration made has been in the form of the stirrer, it having been found that at the lower alcohol percentages the wire stirrer previously used is not satisfactory. Attempts have been made to use a mechanical stirrer, but it was not found easy to fit one in the confined space. At the finish a small perforated disc was used attached to the end of a thermometer. This arrangement appeared to give very satisfactory stirring, repeat estimations in the region of low alcohol content giving results in good agreement.

Some idea of the relative molecular weights may be obtained from the following figures for the freezing point of mixtures with benzene. The tables give the per cent. by weight of benzene present in the mixture and the F. P. :—

PENTANE.

Lot I.		Lot II.		Lot III. (Iso.).	
% B.	F.P. ° C.	%B.	F.P. °C.	% B.	F.P. °C.
91·71	– 0·4	88·20	– 2·1	88·33	– 1·9
79·39	– 6·7	75·26	– 8·5	74·70	– 8·7
68·62	–12·5	59·55	–16·0	58·33	–16·3
58·28	–18·3	45·29	–23·3	46·23	–22·7
47·57	–24·9	34·06	–30·9	35·44	–29·9
40·08	–30·5				

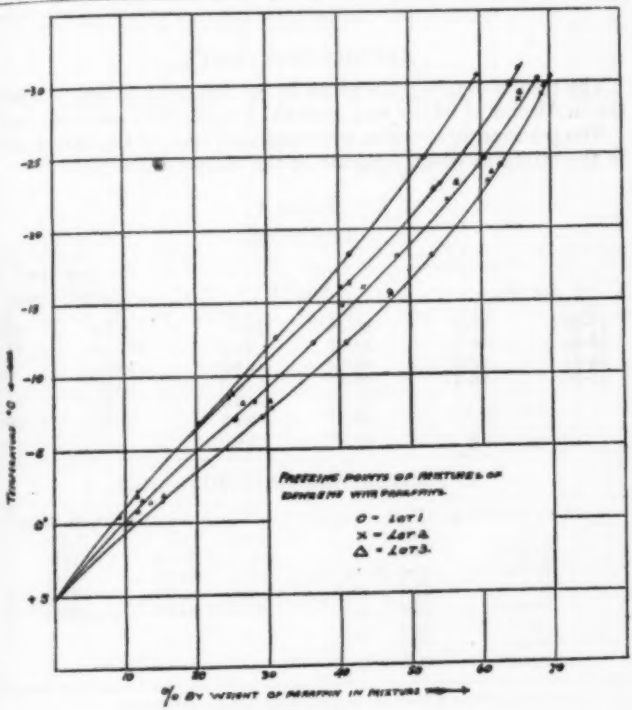


FIG. 1.

HEXANE.

Lot I.		Lot II.		Lot III.	
% B.	F.P. °C.	% B.	F.P. °C.	% B.	F.P. °C.
88·18	– ·8	89·25	0·0	87·69	– 1·5
74·35	– 7·0	71·52	– 8·3	73·07	– 8·1
63·34	–12·1	56·20	–16·0	59·08	–14·8
51·45	–18·1	44·41	–21·9	43·18	–23·4
39·05	–24·8	34·17	–28·8	34·06	–29·4
31·51	–30·2				

HEPTANE.

Lot I.		Lot II.		Lot III.	
% B.	F.P. °C.	% B.	F.P. °C.	% B.	F.P. °C.
84·72	− 1·5	86·21	− 1·4	84·00	− 1·8
70·54	− 7·1	69·24	− 7·9	69·45	− 8·1
58·63	−12·2	52·22	−15·5	52·56	−15·6
46·65	−18·1	38·48	−23·3	38·03	−23·8
36·75	−24·3	30·98	−29·1	30·39	−29·8
29·36	−30·3				

SEPARATION DATA.

The results obtained are given in the following tables :—Solubilities in Alcohol of 92 per cent. weight strength (94·7 per cent. vol.).

The per cent. figures give the weight per cent. of the hydrocarbons in the mixtures which separate at the temperatures given :—

Table I.

PENTANES.

Lot I.		Lot II.		Lot III. (Isopentane).	
%	° C.	%	° C.	%	° C.
78·79	−17·0	63·68	21·1	67·18	21·3
67·96	−18·1	55·91	14·0	57·42	12·5
58·37	−22·8	45·62	4·9	48·07	4·3
47·86	−30·6	39·47	− 5·0	40·69	− 5·0
		35·80	−16·0	35·21	−14·2
		30·41	−22·5	31·59	−28·5
		26·70	−31		

PENTANE–BENZENE MIXTURES.

1 : 1 vol. P.–B. Mixt.				3 : 1 vol. P.–B. Mixt.	
%	° C.			%	° C.
91·50	4·7	*	..	90·66	12·0
82·43	−20·8	Solid	..	87·05	− 7·2
71·81	−21·7	,,	..	83·24	−25·0
62·35	−22·6	,,	..	81·38	−35·0
51·17	−24·3	,,			
41·60	−26·8	,,			
32·62	−30·7	,,			

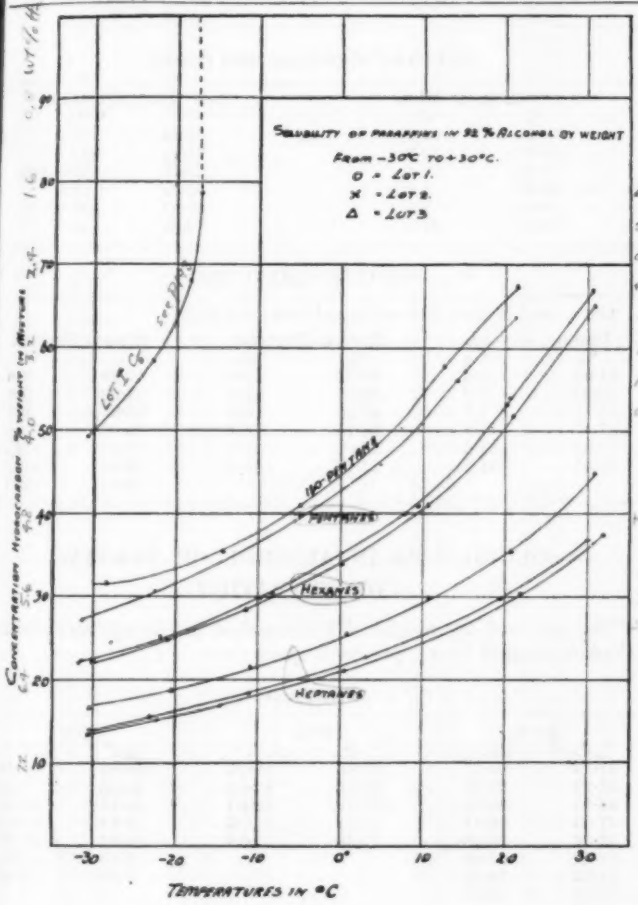
* Unless otherwise stated all separations are liquid-liquid.

HEXANE.

Lot I.		Lot II.		Lot III.	
%	° C.	%	° C.	%	° C.
66·57	30·5	66·63	30·7	64·88	30·8
53·71	20·6	52·89	20·3	51·32	20·8
39·16	7·6	39·48	7·8	40·59	10·7
29·58	− 9·5	30·12	− 8·2	33·70	0·3
23·18	−26·2	24·85	−21·8	28·11	−11·5
21·97	−31·1	21·81	−31·4	24·71	−21·0
				21·98	−29·9

HEXANE–BENZENE MIXTURES.

3 : 1 vol. H.–B. Mixt.			1 : 1 vol. H.–B. Mixt.		
%	°C.		%	°C.	
85·96	25·5	..	87·56	12·5	
74·24	2·5	..	71·35	−19·6	Solid
67·60	− 5·5	..	62·13	−21·1	,,
60·47	−10·3	..	51·96	−23·3	,,
45·92	−19·5	..	42·14	−26·1	,,
40·00	−26·2	..	32·54	−30·4	,,
36·61	−31·4				



FIG, 2.

HEPTANE.

Lot I.		Lot II.		Lot III.	
%	°C.	%	°C.	%	°C.
37·06	32·0	36·43	29·9	44·40	30·9
29·93	21·9	29·38	19·6	35·02	20·7
20·77	0·4	22·36	3·2	29·35	10·7
16·69	−14·6	18·04	−11·0	25·18	0·9
14·91	−22·2	15·17	−23·1	21·23	−10·9
13·27	−30·5	13·66	−30·3	18·48	−20·5
				16·22	−30·3

HEPTANE–BENZENE MIXTURES.

3 : 1 vol. H.–B. Mixt.			1 : 1 vol. H.–B. Mixt.		
%	°C.		%	°C.	
78·98	29·0	..	85·20	12·7	
61·20	14·3	..	73·11	−15·1	
50·46	10·4	..	62·78	−20·0	Solid
40·74	3·9	..	52·34	−22·6	,,
30·94	− 7·5	..	42·17	−25·9	,,
20·74	−31·0	..	32·30	−31·0	

PARAFFIN MIXTURES.

Lot I. used in each case and equal vols. each used.

Pentane-Hexane.		Pentane-Heptane.		Hexane-Heptane.	
%	°C.	%	°C.	%	°C.
61·63	3·8	59·31	17·5	50·36	31·6
50·63	− 2·9	46·37	10·6	37·99	21·0
43·15	− 9·7	36·26	0·8	30·95	10·4
37·47	−17·5	28·70	−12·3	26·06	0·6
33·53	−24·3	25·02	−21·0	22·40	−10·1
30·41	−31·3	21·66	−30·4	19·68	−19·1
				16·97	−29·9

SOLUBILITIES IN ALCOHOL OF VARYING CONCENTRATION.

The per cent. by weight of hydrocarbon in the mixture and the alcohol strength in wt. per cent. given :—

PENTANE.

15° C.			0° C.		−30° C.	
% P.	A.S. %		% P.	A.S. %	% P.	A.S. %
77·39	90·27	2.3	53·66	89·29	58·82	92·16
68·23	89·04	3.5	42·66	87·98	45·66	91·42
58·55	88·08	5.0	32·24	86·05	38·11	90·35
47·05	86·91	7.0	25·51	84·26	28·48	88·53
37·54	85·45	9.1	15·89	79·55	18·82	85·25
27·67	84·63	11.1			14·10	82·60
18·35	78·22	17.5			7·90	76·54
13·38	74·56	22.				
7·23	67·35	30.0				

HEXANE.

Lot I.

30° C.			−30° C.	
% H.	A.S. %		% H.	A.S. %
90·73	94·93	..	90·58	97·55
79·63	93·82	..	80·53	97·84
69·49	92·55	..	69·41	97·44
59·95	91·43	..	59·31	97·16
49·47	90·68	..	48·89	96·63
39·19	89·68	..	39·01	95·62
29·53	87·65	..	29·10	94·09
20·02	84·59	..	20·13	91·63
14·46	81·57	..	14·91	89·26
8·08	75·31	..	8·47	84·37
96·95	95·08			
93·93	95·38			
91·23	95·09			
88·36	94·76			

Lot II.

30° C.			−30° C.	
% H.	A.S. %		% H.	A.S. %
80·02	94·84	..	80·35	96·94
69·95	93·37	..	69·40	96·60
57·73	91·81	..	59·79	96·44
45·55	90·71	..	50·29	95·91
37·71	89·62	..	40·14	95·21
29·33	87·87	..	28·70	93·84
19·98	84·66	..	20·35	91·74
14·54	81·59	..	14·83	89·12
8·13	74·77	..	8·47	83·58
			96·96	98·35
			94·22	97·92
			91·60	97·37
			88·97	96·82

Lot III.

30° C.			−30° C.	
% H.	A.S. %		% H.	A.S. %
79·39	93·05	..	80·49	97·38
68·53	91·77	..	70·51	97·01
58·75	91·24	..	59·67	96·45
48·45	90·38	..	48·95	96·12
38·83	89·42	..	39·86	95·51
28·55	87·49	..	29·52	93·99
20·00	84·63	..	20·35	91·65
14·48	81·51	..	14·93	89·38
8·24	75·14	..	8·43	84·44
96·89	95·18	..	97·24	98·18
94·10	95·42	..	94·39	98·56
91·19	95·12	..	91·77	98·05
88·63	94·63	..	89·33	97·84

HEPTANE.

Lot I.

30° C.			−30° C.	
% H.	A.S. %		% H.	A.S. %
89·98	94·01	..	59·89	98·31
79·83	94·20	..	49·46	98·23
69·23	94·44	..	39·22	97·44
59·12	93·63	..	29·51	96·48
49·74	93·31	..	20·57	94·70
46·90	92·63	..	14·97	92·86
29·79	91·20	..	8·59	88·98
20·41	88·73			
14·92	86·30			
8·47	81·15			

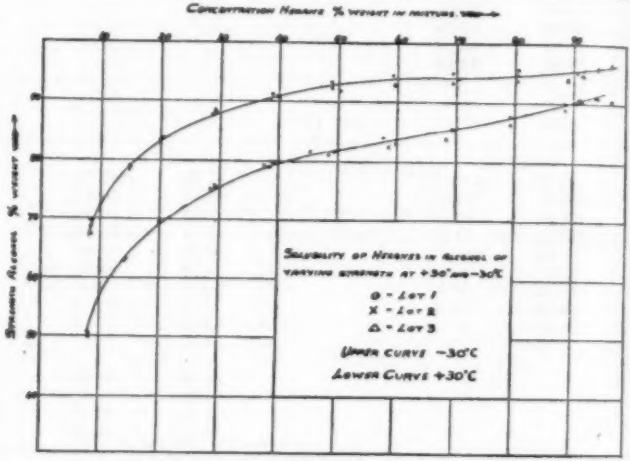

Concentration Hexane % weight in mixture
Strength Alcohol % weight
Solubility of Hexanes in Alcohol of varying strength at +30° and −30°
○ = Lot I
× = Lot II
△ = Lot III
Upper Curve −30°C
Lower Curve +30°C

Fig. 3.

Lot II.

30° C.			−30° C.	
% H.	A.S. %		% H.	A.S. %
79·90	94·53	..	80·78	98·91
68·72	94·12	..	71·10	98·92
59·39	93·62	..	60·63	98·57
49·76	93·44	..	49·94	98·24
39·46	92·45	..	39·65	97·22
			30·02	96·57
97·08	96·23	..	20·54	94·75
94·19	96·39	..	15·07	92·90
91·55	96·33	..	8·73	89·09
89·00	96·08			
			97·09	97·24
			94·41	98·02
			91·86	98·02
			89·50	98·38

LOT III.

30° C.			−30° C.	
% H.	A.S. %		% H.	A.S. %
80·16	94·03	..	81·01	97·88
71·16	93·86	..	71·46	98·00
60·40	93·35	..	60·97	97·96
50·31	92·38	..	50·48	97·73
40·45	91·53	..	40·24	96·98
30·44	90·12	..	30·87	95·94
20·52	87·43	..	21·09	93·90
15·12	84·81	..	15·54	91·90
8·62	79·44	..	8·72	87·53
97·09	96·22	..	97·25	98·18
94·41	96·44	..	94·71	98·83
91·80	96·34	..	92·15	98·73
89·43	96·12	..	89·85	98·62

The sections of the tables ruled off indicate that a separate determination was carried out at the higher strengths of alcohol.

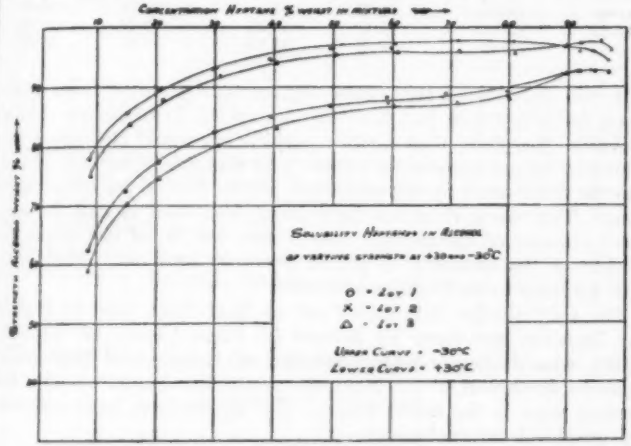


FIG. 4.

Since carrying out the above work we have endeavoured to purify the samples of hexane and heptane by acid washing and fractionation. In the case of hexane we were not successful in preparing any constant boiling fraction, but in the case of heptane a large fraction was isolated, coming over from 98·3–98·4° C., the bulk distilling in the first ·05° C. The characters of this purified heptane were found to be :—

S.G. 0·6887 at 15·15° C.
B.P. 98·35° C. (760 mm.).
Engler distillation drop 98·0° C. Dry 99·0° C.
Aniline point 71° C.

These values may be compared with those given in the table at the beginning of the paper, and also with the values found by E. and R. Kremers (*J. Amer. Pharm. Assoc.*, 1920, 9, 860-864), who found :—

d_{20} = 0·68288.
S.G.= 0·6877 (calc.) 15·15° C.
B.P.= 97·33° C. (760 mm.).

The solubility figures for the purified heptane are as follows :—

30° C.		0° C.		−30° C.	
% H.	A.S. %	% H.	A.S. %	% H.	A.S. %
91·18	98·17	90·59	98·30	90·97	98·23
80·15	95·82	80·65	97·92	81·14	98·51
69·42	95·35	69·29	97·98	69·37	98·25
58·84	94·26	58·78	96·91	59·19	98·18
49·44	93·47	48·68	96·41	49·52	97·99
39·00	92·78	38·61	95·72	39·31	97·06
29·28	91·16	29·57	94·36	29·54	96·28
19·96	88·61	19·75	91·98	20·56	94·62
14·25	85·94	15·42	90·27	15·24	92·93
8·39	80·94	8·50	85·35	8·92	89·37

It will be noticed that these figures hardly differ from those given for Lot 1 and Lot 2 of the unpurified hydrocarbon. It is probable, therefore, that further purification would not affect the solubility to any measurable extent, and therefore these last figures may be relied upon as being the true values for the pure hydrocarbons. This work does not lend itself, nor does it call for any great amount of discussion. The results will be of use when the subject of the solubility of petrol spirits in alcohol is considered. This we hope to do in the near future.

The only similar determinations we have been able to find in the literature are those by Bonner (*J. Phys. Chem.*, 14, 738-786, 1910), who determined the solubility of hexane and heptane in aqueous alcohol at 0° C. Bonner's results are compared with the present work in the tables below. The figures have been collected by graphical interpolation :—

HEXANE at 0° C.

% Hexane in mixture ..	10	20	30	40	50	60
Alcohol strength, 1 (Bonner)	83·2	89·0	91·9	93·5	94·6	95·0
2 (O+C) ..	82·1	88·1	91·0	92·6	93·7	94·3

HEPTANE at 0° C.

% Heptane in mixture ..	10	20	30	40	50	60
Alcohol strength 1 (Bonner)	84·5	90·1	93·0	94·2	95·0	95·2
2 (O+C) ..	86·3	92·0	94·4	95·9	96·5	97·1

In each case the first line of results given are Bonner's figures.

It is probable that Bonner's heptane contained a small amount of aromatic hydrocarbons, the solubility being much higher than that of our specimens.

In the various figures we have given the solubility curves. The very much greater solubility of the Lot I. pentane will be noticed. It is probable that this is due to the dissolved gas or very light liquid which it contains. Other points in relation to this work will be obvious on reference to the curves and figures and need not be further discussed at this juncture.

This paper and the previous note are a continuation of the work being carried out at the joint request of the Distillers Co., Ltd., and the Fuel Research Board of the Department of Scientific and Industrial Research, to whom we are indebted for the funds necessary for carrying out this work. In a further paper we hope to communicate the results of further work on these lines relating to petrol spirits, paraffins and other hydrocarbons, and to discuss in a general manner such conclusions as may be drawn from the work as a whole.

The Sixty-second Meeting of the Institution of Petroleum Technologists was held at the Royal Society of Arts, John Street, Adelphi, W.C., on Tuesday, February 14th, 1922, PROF. J. S. S. BRAME, President, in the Chair.

The following members of the Council were present: Sir F. W. Black, Sir Thos. Holland, Dr. Ormandy, and Arthur W. Eastlake.

The Significance of the Interpretation of the Chemical Analyses of Seepages.

By J. E. HACKFORD, B.Sc., F.I.C.

I HAVE had the honour of being asked to read a short paper, which has for its subject-matter "Petroleum," and to include therein some remarks concerning "English Oil." I hope, however, that I shall not try the patience of the gentlemen before me, if I make a preliminary survey of the characteristics of oil and oil products in general, before approaching the question of the characteristics of English oil. I fear that in some respects I shall not be able to make the paper so scientific a treatise as may be required to satisfy the academic criticisms of some of our members, for I realise that I have not half so many notes or footnotes as I should

have, but I have given due credit to others wherever possible, and I trust that the remaining members will be satisfied when I advise them that any omission in this respect is due to any cause but negligence.

I will attempt to show you this evening the various reasons and results on the path I followed in my examination of England as an oil-bearing country, which culminated in my being able to predict the quality of such oil as would be found in England two years before the first well was completed.

Although it must often have been noticed that there are different classes of oil in the world, yet it is remarkable that, generally speaking, these classes are isolated in various localities; for example, we have one type of oil in Pennsylvania, another in Borneo, and another in Mexico. The question arises as to why we do not obtain the Mexican type of oil in Russia, or the Borneo class of oil in Mexico. Again, in some single fields the oils are of practically the same nature and gravity, whilst in others, particularly those of salt-dome formation, very different varieties of the same class of oil are found in the same field. What other can we do, then, than to announce as a truism that "The quality of a crude oil varies with the local geological conditions." On the flanks of a salt dome, oils of a low specific gravity are often found, and in the case of the Mexican salt domes it is true that the specific gravity varies as the thickness of the crust of the dome and the sulphur contents thereof.

Here is a selection of analyses from a typical dome formation in Mexico. On such a small dome it is obviously impossible to suggest different modes of genesis for the different classes of oil found thereon.

The Salt Domes of the Isthmus of Tehuantepec.

The oil exploited in the Isthmus of Tehuantepec has been found in two formations:—

Class A.—The lenticular, sandy members of the Miocene marls.

Class B.—The Dolomite, so called, which lies on the top of salt masses in the different domes.

Class A.—The oils occur in the marls themselves, both in the immediate flanks of the salt domes and also at some distance away.

Class B.—In general, the dolomite rock, whether barren or oil-bearing, contains free sulphur. This is practically absorbed by the oil, and so results in oils of varying specific gravities being found on the same dome, according to the thickness of the dolomite which determines the quantity of sulphur absorbed in the different localities. The dolomite itself is a limestone, containing up to 2 per cent. of magnesium, and the free sulphur content of the oil may be anything up to 20 per cent.

ANALYSES OF THE OILS FROM ONE OF THESE FIELDS.

Class A.—Lateral Sands.

		Sp. Gr.	Sulphur. Per cent.	Asphalt. Per cent.
Well 8.	602–605 ft.	0·910	3·95	20
Well 8.	150–750 ft.	0·871	3·20	18
Well 12.	604–610 ft.	0·889	3·40	—
		0·882	2·60	—

Class B.—Dolomite.

Well 1.	Dolomite 5 ft.	0·891	3·91	17
Well 2.	Dolomite 22 ft.	0·974	7·33	65
Well 6.	Dolomite, thin	0·882	3·46	10
Well 10.	Dolomite, thin	0·882	3·70	10
Well 19.	Dolomite 14 ft.	0·918	4·17	40

The salt water obtained from the dome contained very appreciable quantities of iodine.

We find the sulphur and the asphalt content to vary directly as the specific gravity, as illustrated by the analyses. From the great divergency in the sulphur contents of these oils, it will be seen at once that it is impossible for them to have as many different origins as there are different oils. The theory put forward to explain the phenomena is as follows :—

It is assumed that the oil, coming from one direction, encountered the dome, and stored itself in the natural reservoir of dolomite enclosed by the overlying marls. In those places where the thickness of the dolomite was appreciable, and where the sulphur content of the same is correspondingly large by bulk, sulphur was absorbed by the oil, resulting in the formation of asphaltum, causing a corresponding increase in the specific gravity of the oil. In those places where the dolomite was thin, and, consequently, the bulk of the sulphur present in it small, little change has taken place in the oil itself. It is then seen that, in an oilfield containing oils of varying gravities and properties, the variations are directly traceable to local geological conditions.

It is generally found that on a large anticline the qualities of the oil are practically the same, but, let there be a fault, then the oil of the faulted area is always different from the bulk oil existing on the anticline, and is generally much heavier. It is found to contain a much larger percentage of oxygen in the asphaltene fractions than in the corresponding fractions of the oil. The following analyses of the asphaltene fractions of two oils, separated from each other by 150 yards, the fault intervening, illustrates this point :—

	Well 1. Per cent.	Well 2. Per cent.
Sulphur	1·68	2·08
Oxygen (Diff.)	1·80	4·32
Gravity of original oil	0·882	0·898

This difference in quality between two wells, only 150 yards apart, is a typical example of what I wish to infer by the statement that, "The quality of the oil varies with the local geological conditions."

Should a number of samples of oil from one field be given to the chemist, he will be in a position from the analyses of these samples and/or seepages to accurately state the geological structure from which the oil has been derived, and also to state whether any of the samples were found on a faulted zone. Detailed examples I hope to be able to give at a later date with the permission of the Council.

Another factor controlling the quality of the oil is the mode of its formation. I think all will agree with me in ascribing the reasons governing the different characteristics in different countries to be due to different modes of formation, meanwhile allowing that minor differences in the characteristics of the oil in any particular field are due to the local geological conditions. For example, let us question why there is so much sulphur in Mexican oils, and why does that type of oil stretch from the States to Venezuela, *via* the Gulf of Mexico, but with local aberrations? I suggest the following theory to explain the facts.

The outstanding features of Mexican oils are :—

1. The high sulphur content.
2. The asphaltic nature.
3. The minute nitrogen content.
4. The practical absence of aromatic compounds.
5. The multiplicity of the elements present in the ash of the oil.

It is now my intention to take each of these items in order and to show that the facts conform to my hypothesis that Mexican oil was derived from seaweed.

1 and 2. *The High Sulphur Content and the Asphaltic Nature.*

There is abundant evidence of recent accumulation of raw material, within the limits stated, and especially in the Gulf of Mexico. The alga *Macrocystis pyrifera*, according to D. R. Hoagland and L. L. Lieb (*J. Biol. Chem.*, 1915, 23, 287–297) "is noteworthy for its huge size, and is said to have the widest distribution of any known plant." It is also stated that it is prolific in the Gulf of Mexico, and is commercially important in California.

Asphaltic oils have a high sulphur content, and, as we have shown above, there is an abundance of crude material for making the oil, it becomes a matter of interest to know whether the sulphur present was derived from the crude material, or whether sulphur was subsequently introduced into the oil.

Evidence shows that the raw material can supply the sulphur to any oil that may have been derived from it :—

	Macrocystis pyrifera.	*Iridaceæ.*
	Per cent.	Per cent.
Total sulphur	13 ..	6·9–8·45
Sulphur in ash	8 ..	4·85

The sulphur in the ash corresponds to $CaSO_4$.

There seems to be little doubt from the above figures that the asphalt was formed contemporaneously with the oil, and that all the sulphur compounds present in the oil are, indeed, integral parts of the oil.

3. *The Minute Nitrogen Content.*

Another point of interest centres in the nitrogen content of the oil. Mexican oil only contains 0·005 per cent. of nitrogen.

The low nitrogen content of the Mexican oils is by no means surprising when one considers that algæ possess little or no nitrogen in their constitution (about 0·1 per cent.).

It is here interesting to note that Ralph Arnold, in his classic research on the Monterey shales, concludes that the oil contents were derived from marine animal matter. The oil from an oil shale at Santa Cruz in the Santa Maria district of California has a nitrogen content of 2·4 per cent., which, in my opinion, confirms his views as to the origin of such oil.

It would then appear probable that a low nitrogen content in an oil indicates a marine plant origin.

4. *The Practical Absence of Aromatic Compounds.*

Algæ contain neither cellulose nor nitrogen in quantity, and it is but to be expected that the oil should not contain aromatic decomposition products. The total aromatic content of Mexican oils is 0·003 per cent.

5. *The Multiplicity of the Elements present in the Ash of the Oil.*

It is well known that marine plants have the power of absorbing various elements from sea-water, and, therefore, if Mexican oil be derived from the former, the ash should be characterised by a diversity of elements. Silica, vanadium, nickel, tin, lead, calcium, magnesium, iron, aluminium, sodium and titanium are present. Gold is present in traces. The saline waters accompanying the oil as tested from wells from Dos Bocas, to the Isthmus of Tehuantepec, contain iodine.

From the above evidence, it appears most probable that Mexican oil was derived from marine vegetation.

If these premises and conclusions be true, it is quite understand-

able why similar conditions did not obtain all over the world. Taking the cases of Pennsylvania and England, here we have a group of oils occurring in coal-bearing countries, and I would suggest the mode of formation to be due to the decomposition of terrestrial vegetation, etc., as recorded in the *Journal of Mining and Metallurgical Engineers*, No. 163, July, 1920. I advance this theory as to the mode of formation and the nature of coal, comparing it at the same time with the mode of formation of oil.

Consider a stratum containing a deposit of either marine vegetation or animal remains. These substances, on decomposition, form oil and gas, which, if contained in a sandy bed, are swept away from their source, either by gravity or by water, as rapidly as formed, since neither the animal remains nor the marine vegetation contain cellulosic material capable of forming a sponge-like mass, which would hold the oil *in situ* during the decomposition stage.

Second, assume a buried deposit of terrestrial vegetation. Decomposition takes place, resulting in the formation of oil and gas, as in the previously cited case. Owing to the cellulosic nature of the material, and its porous, spongy nature, the oil is kept *in situ* whilst the decomposition proceeds. Accompanying the decomposition there is probably a rise in temperature which, even if not above 100° C., is quite sufficient, as I have proved in the laboratory, to convert into kerotenes the oxy- or thio-asphaltenes that are formed simultaneously with the oil. As the process goes on, the kerotenes become less and less soluble, until they are insoluble in pyridine or quinoline, and so they remain as a solid in the sponge-like mass afforded by the cellulosic structure of the terrestrial vegetation.

It has been recorded by Hoagland and Lieb that the algæ on which they made tests contained from 5 per cent. to 13 per cent. of sulphur. It therefore follows that those coals which contain algal ingredients in quantity (some undoubted cases of which White puts on record) a larger amount of thio-bitumens should be present, with a corresponding reduction in the oxy-bitumens, and the cellulosic residues.

According to this theory, the amount of soluble bitumens should be greatest in peat, and should decrease through lignite, subbituminous, bituminous, and semi-bituminous coals to anthracite, which, indeed, is the case. It is interesting to note that, where pure kerite deposits have been found, they have nearly always been mistaken for coal. It took ten years' litigation to decide whether the New Brunswick oxy-kerite was coal or bitumen. Similar instances are given by L. L. Hutchinson in the case of the Jackfork Valley, the Impson Valley, etc. A similar case of a thio-kerite is a deposit in Nova-Zembla, which was reported to me as

coal suitable for metal smelting. Samples were forwarded, and, on analysis, yielded :—

	Per cent.
Ash	0·72
Sulphur	15·54
Nitrogen	0·76

The sample possessed a bright, soft lustre and had the appearance of anthracite. It was, however, totally insoluble in solvents, and, on heating, gave off little gas. No oil whatever was evolved. In fact, the sample behaved in every way like anthracite. The volatile matter was only 1·8 per cent. However, from a comparison with certain experiments then in progress, I decided that the material was a kerite. A subsequent geological examination showed the deposits to occur in small lenses in a metamorphosed deep-sea limestone, which contained none of the depositional associate of coal, and, in fact, confirmed the oil origin of the deposit. This is regarded as a pure sample of a thio-kerite. It is probably true that certain so-called coals from Columbia that have a sulphur content of 13 per cent. are simply thio-kerites.

The main difference between these so-called coals, and true coal, rests in the fact that they possess no cellulosic residue, which upon distillation can produce phenols. It is conceivable that a kerite produced from microscopic remains containing some cellulose, but not in sufficient quantities to act as a sponge, would yield traces of phenols upon dry distillation. This would be but another connecting link between coal and petroleum.

Petroleum oils such as occur in Nature are clearly not derived from coal ; but, given a quantity of vegetal material, petroleum may be produced under a given set of circumstances if no cellulose is present, and coal will be formed if the vegetal matter contains sufficient cellulosic matrix to form a sponge.

In the case, however, of such oils as those of Algeria, Borneo, and some parts of Persia, where the striking characteristic of the territories is the presence of aromatic compounds, I regret that, up to the present, I have not completed the necessary research previous to advancing a theory, and practically the same remark applies as to why Russian oils are conspicuous by the quantity of naphthenes present, although there is little doubt in my mind that they were formed by the oxidation of a straight chain series, as has been supported by the recent work on the transformation of petroleum oils into fatty acids. On reading such reports, it will be observed that, while the more easily identifiable acids so produced have been aliphatic, the authors have always inferred that the bulk of the acid products were naphthenic in Nature.

All mineral oils contain aliphatic hydrocarbons, and in consequence the nomenclature is based on that fraction of the oil

present which forms its distinguishing characteristics. Here I divide oils into the following classes :—

1. Aliphatic oils.
2. Aromatic oils.
3. Naphthenic oils.
4. Naphthylenic oils.

Each of the above may contain either oxygen or sulphur derivatives of the same.

1. An aliphatic oil is a mixture of aliphatic hydrocarbons, either saturated or unsaturated, and they may contain their oxy- or thio-hydrols, and/or ethers, *e.g.*, Pennsylvanian oil.

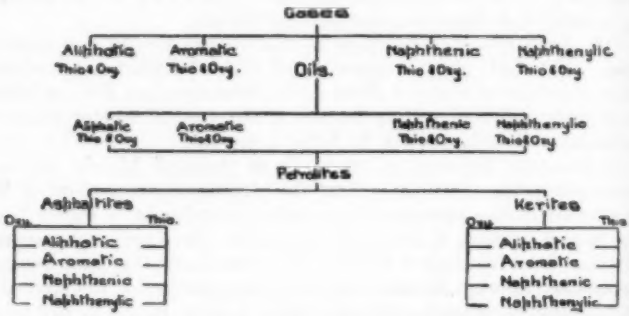
e.g. Oxy-asphaltic oil	.. ..	Pennsylvanian.
Thio-asphaltic oil	.. ..	Mexican.

2. An aromatic oil is a mixture of aliphatic and aromatic hydrocarbons, *e.g.*, Borneo and Sarlat.

3. A naphthenic oil is a mixture of open and alicyclic hydrocarbons, which, generally speaking, are derivatives of hexahydrobenzene, *e.g.*, Russian.

4. A naphthylenic oil is a mixture of aliphatic hydrocarbons, and naphthylenic hydrocarbons, *i.e.*, derivatives of a bridged ring series, *e.g.*, Nigerian and Pechelbronn (Boussingault).

It has been observed in Nature that a natural oil seldom contains large percentages of any two distinctive fractions together ; one always predominates.



THE CHEMICAL CLASSIFICATION OF BITUMENOUS SUBSTANCES.

Gases.

Gases are sub-divided under the same headings as above.

Solid Varieties.

All classes of solid bitumen are covered by the term "Petrolite." If soluble in carbon-bisulphide, they are called asphaltites, and

if insoluble in this solvent, as kerites. These in turn are derived from one of the classes of oil, mentioned above, and consequently may be oxy- or thio- in nature. The following diagram gives examples of the utility of the above method of classification.

EXAMPLES OF THE CLASSIFICATION OF OILS AND PETROLITES.

- Petrolites
  - Asphaltites
    - Oxy-asphaltites
      - Oxy-aliphatic asphaltite.
      - Grahamite.
      - Oxy-aromatic asphaltite.
      - Macuspana seep.
      - Oxy-hetero-cyclic asphaltite.
      - Russian seeps (solid).
    - Thio-asphaltites
      - Thio-asphaltic asphaltite.
      - Gilsonite, Manjak.
      - Thio-aromatic and thio-hetero-cyclic varieties are at present unknown.
  - Kerites
    - Oxy-kerites
      - Oxy-aliphatic kerite.
      - Elaterite and Albertite.
      - Other two classes unknown.
    - Thio-kerites
      - Thio-aliphatic kerite.
      - Wurtzilite and Impsonite.
      - Other two classes unknown.

For example :—

Grahamite.—Soluble in CS_2. Oxygen. Aliphatic base. Name, Oxy-aliphatic asphaltite.

Macuspana Seep.—Soluble in CS_2. Derived from aromatic oil. Name, Oxy-aromatic asphaltite.

Russian Seeps.—Soluble in CS_2. Yields naphthenes and naphthenic acids in quantity on dry distillation. Contains oxygen, but practically no sulphur. Name, Oxy-naphthenic asphaltite.

Elaterite and Albertite.—Insoluble in CS_2. Contain oxygen, and are derived from aliphatic oil. Name, Oxy-aliphatic kerites.

Wurtzilite and Impsonite.—Insoluble in CS_2. Contain sulphur, derived from an aliphatic oil. Name, Thio-aliphatic kerite.

In a systematic and scientific search for oil it is the geologist's function to determine whether the structural conditions are favourable for the accumulation of oil in quantity, and, by determining the depths to suitable reservoir beds, to afford a basis on which to make estimates of the cost of test boring. It is the chemist's province to determine, from the available seepages, the character of the oil which will be obtained if the borings are successful, and so permit a judgment to be made in advance as to whether a small or large sum should be risked in boring. It is also the chemist's province from such data, in such cases, to afford checks on the geologist's work, and by working in close co-operation with the sister science, to obtain a more complete

deduction from surface evidence than either science could obtain alone.

The surface evidence of the bitumen will naturally be in either a gaseous, liquid, or solid form. Up to the present time no systematic work has been done along the line of the interpretation of the character of the oil from the analyses of natural gas. These analyses have not been carried by deduction beyond the simple determination of the various constituents. For example, the methane value may vary between 30 per cent. and 90 per cent., the nitrogen value between 4 per cent. and 60 per cent. of nitrogen, and the hydrogen between 0·1 per cent. and 30 per cent., and yet no adequate reason has so far been put forward as to why this is so.

The following tentative theory is advanced to explain these analyses, and to show by means of examples how the data deduced may be employed in the identification of the associated oil.

For the purpose of the discussion, we may take it that naphthenic and naphthylenic bodies are so closely associated that they may be regarded as one. Hence, following the lines of the classification of liquid and solid bitumens, we subdivide gases into three classes only, *e.g.* :—

1. Aliphatic.
2. Aromatic.
3. Alicyclic (including naphthenic and naphthylenic).

In the first place let us make the speculative assumption that oil is derived by the condensation of methane, and associate this assumption with the above classes of oils.

1. *Aliphatic Gases.*

If the methane has condensed to form an aliphatic oil, it is to be expected that a state of equilibrium would ultimately obtain, and that consequently the gas would contain a large percentage of paraffin gases in which methane predominates. As the condensation process is a simple operation, and little fundamental change has taken place (particularly in the nature of cracking, or of the formation of benzene rings), there should therefore be little, if any, free hydrogen liberated.

If the gases and oil originate in organic matter, it is to be expected that the gas would still contain nitrogen, but not a very large amount.

Were the gas and oil derived from marine vegetation containing little nitrogen and a large amount of sulphur, it is to be expected that the gases would contain little nitrogen and a relatively large amount of sulphuretted hydrogen.

2. *Aromatic Gases.*

As the boiling-point of the lowest member of the series (benzene) is very much higher than the temperature at which the gases are usually evolved, it is unlikely that we should find quantities of the benzenoid series present.

Some condensation of the methane has taken place to form the aromatic oil, which is, at the same time, a partially unsaturated body. We cannot expect free hydrogen to be present, for, had there been any, the likelihood is that it would have been used up in saturating the benzenoid ring, with a formation of a hexamethylene ring.

Aromatic oils are noted for their nitrogen content, and therefore we expect to find this element present in the gases.

We should therefore expect to find the gas from an aromatic oil rich in paraffin gases, but lower than in the case of aliphatic gases, and to contain no hydrogen.

3. *Alicyclic Gases.*

As in the case of alicyclic gases, we cannot expect to find vapours of alicyclic bodies.

As those bodies are formed by the hydrogenation of benezoid rings, there must have been a large excess of hydrogen present. It is, therefore, very likely that a large amount would remain in the free state in the gas.

Nitrogen should be present as above, if the oil be derived from nitrogenous matter.

	Thio-Aliphatic.	Aliphatic.	Naphthylenic.				Aromatic.	
	Mexican Potrero.	Average Pennsylvanian.	Grozni.	Borys-law.	Borys-law.	Surakhani.	Borneo, Mean of Four Analyses.	Burma Average.
	%	%	%	%	%	%	%	%
CH_4 ..	36	97·30	62·0	38·66	16·63	87·21	73·5	64·2
C_xH_{2x+2}	45·5	—	4·8	3·2	2·2	2·05	—	28·4
N ..	—	2·02	7·0	43·74	62·5	5·29	3·5	4·0
H ..	—	0·00	4·0	13·4	15·2	—	—	—
HS_2 ..	4·6	0·00	—	—	—	—	—	—
CO- ..	14·0	0·28	18·0	0·6	3·0	3·86	22·4	0·9
CO ..	—	0·00	2·2	0·6	0·0	1·59	—	—
O ..	—	trace	1·4	—	—	—	0·5	2·5

It will be seen by the accompanying analyses that the suggestion made in the hypotheses are confirmed. For example, we do not

obtain hydrogen in the gases derived from aromatic oils, whereas we do find it in those gases which are derived from straight naphthenic oils. In lack of a better explanation the above theory has its use, and I think this is an opportunity of requesting members to forward accurate analyses of their gases to the Institution together with the samples, so that our members have an opportunity of examining the same. A museum of different oils would also be of great advantage.

Deductions. Gas from Mexican Oil.

This aliphatic gas shows an unusually large amount of sulphuretted hydrogen, and from this figure one would predict that the accompanying oil was of an asphaltic character—thio-asphaltic. Nitrogen is low, and hydrogen is absent.

Pennsylvanian Gas. Oxy-aliphatic Gas.

The percentage of paraffin gases is high. Sulphur compounds and hydrogen are absent, and hence it can be predicted that the accompanying oils are of an aliphatic character, and consequently any solid seeps should be of an oxy-nature, such as grahamite (asphaltite), or if insoluble, albertite (kerite).

Boryslaw. Galicia. Naphthenic or Alicylic Gas.

Hydrogen is present, and the total percentage of paraffin gases is low. The nitrogen is relatively high, indicating that the oils are possibly derived from animal matter. As sulphuretted hydrogen is absent, it can be predicted that the accompanying oil would be naphthenic in character.

Gas from Borneo. Aromatic Gas.

The outstanding features are the absence of hydrogen and the presence of nitrogen and relatively small percentage of methane. The oil accompanying this gas would be aromatic in character.

Interpretation of Solid and Liquid Seepages.

These naturally afford a rather fuller basis for the application of the method developed than gases. It will suffice at this stage to take as an example a sample of a solid seepage found in the laboratory to possess the following characteristics :—

	Per cent.
Asphaltum	65·5
Asphaltenes	46·9
Diasphaltenes	18·6
Oil and Paraffin Wax	34·5
Fixed Carbon	32·4
Sulphur	7·27

The oil and paraffin wax which have been so obtained by solvent methods were then distilled in a vacuum, and were found to contain sulphur compounds in quantity. The whole proved to be soluble in carbon-bisulphide, consequently one is able to conclude the following:—On account of the large sulphur content, and its solubility in carbon-bisulphide, the seep is a thio-asphaltite. On account of the fact that the uncracked oil from the same contains sulphur compounds, of an aliphatic character in distinctive quantities, the substance is an aliphatic thio-asphaltite, and the underground oil will be similar in nature to that found in some parts of Mexico, of fair to medium quality, somewhat difficult to refine, and yielding only medium quality products.

As a second example, let us consider an asphalt of the following composition partially insoluble in carbon bisulphide:—

	Per cent.
Asphaltenes	97·0
Oil and Wax	3·0
Sulphur	1·2
Fixed Carbon	53·7

The oil as extracted by solvents was found to be of an aliphatic nature. The sulphur content was low and the sample partially insoluble in carbon disulphide. It would therefore be called oxy-aliphatic-kerite, and the oil from which it is derived would be similar to those oils found in England and Pennsylvania. The name "Albertite" would be given to such a substance at the present time.

Hence it will be seen that by placing a solid bitumen in its chemical category we derive commercially valuable information, which could not be ascertained were the bitumen physically classified, or merely classified under the chance name of the discovering prospector.

It is useless for me to recapitulate the numerous analyses of English oils and seepages that have been found in the past. I may say I have had most of them for examination, and like other analysts found them to be aliphatic base oils containing traces of naphthenes.

It has been shown in this paper how we determine the *class* of the oil existing underground as yet undrilled, by interpreting the analyses of such visible evidence as solid and liquid seepages, or even gas. The following up of this method of interpretation has entailed the establishment of many new and interesting laboratory methods, the results of which enable us to amplify our deductions as to the *class* of the oil present, and to give an approximate forecast of the percentage of its constituents.

I fear, gentlemen, that I have already taken up too much of your valuable time, and should it give you pleasure I would propose,

at a subsequent meeting, to read a paper describing these new methods. The interpretations of the results would enable anyone to predict with a large degree of accuracy both the nature and an approximate analysis of the subterranean oil in bulk which might be present, from a purely chemical investigation of the surface seepages.

The President said the paper had been most suggestive in showing how from surface indications the character of the oil underneath could be prognosticated. There were several points of very considerable interest, particularly the suggestion which the author had made with regard to the important part which cellulose, acting as a sponge, played in determining the formation of coal, and in its absence the formation of oil. He did not think at present the evidence which could be produced from the composition of natural gases was altogether to be relied upon. The author had emphasised the point that he put the matter forward in a very tentative way. Most of the analyses of natural gases were to be regarded with a certain amount of suspicion, in view of the different results which had been obtained in the analysis by liquefaction methods and the ordinary gas analysis methods. A very different composition, especially for the higher hydrocarbons, was shown for a gas when examined by liquefaction methods. In none of the analyses given in the paper was benzene found. The author had pointed out that benzene was a liquid hydrocarbon, but it was known that benzene was carried by coal gas in appreciable quantities, not only benzene but toluene also; and it would be an interesting thing to ascertain whether the application of liquefaction methods would show these hydrocarbons to be present in certain natural gases; if so, it would bear out the author's hypothesis. The author had started out by a promise that he was going to say something about English oil, but his references to English oil had been almost as scanty as its production.

Sir Thomas Holland said the subject was not exactly in his line, but he would obey the President's order to open the discussion, as he might at any rate be able to act as a catalytic agent to the brains of the chemists present, who would be able to deal with the main subject of the paper itself. The author had led the meeting at such great speed over what many people regarded as very thin ice that one was left rather breathless. The audience had been translated from Mexico to New Brunswick, taken across the Atlantic to the ice-covered slopes of Nova Zembla, brought back again to the tropical forests of Columbia, and then taken across to Algeria, Borneo, Persia and Burma; they had been deluged with sulphur

compounds, some with very long names, and all of them of very strong odour, and had been told that questions about which the geologists made so much fuss were subjects that could be settled at once by the chemist. On the second page of the paper the author said : "Should a number of samples of oil from one field be given to the chemist he will be in a position from the analyses of these samples and/or seepages to accurately state the geological structure from which the oil has been derived, and also to state whether any of the samples were found on a faulted zone." The author had then settled without much hesitation the most vexed of all questions, namely, the origin of oil, about which there had been more controversial gas evolved than ever came out of the best well struck. Then, as a mere accidental aside, the author had told them exactly why a deposit of vegetable matter at one time was transformed into petroleum and at another time turned into coal. Now, those questions, on which so much controversy had been expended, had been settled as incidents by the way before coming to the main subject of the paper itself. Before he went further he would like to say that, in spite of those remarks, the paper was of the kind that was required in an Institution like that of the Petroleum Technologists. One need not agree with the author's conclusions, and might criticise his methods, but the paper was one that had stirred the thinking capabilities of every member, and in that respect was going to give rise to discussion which he hoped, as one of the members of the Council, would lead to a fulfilment of the offer which the author had made to give further contributions on the separate phases of the subject he had touched. After the first ten minutes of listening to the paper he feared that some very heavy stresses were being applied to the configuration of his simple faith ; he was afraid it might be stretched beyond its elastic limit, and he felt inclined to ask the author to stop in order that those points about which there appeared to be insufficient information could be more fully discussed. He would like, for instance, to go over more deliberately the table of the composition of natural gases again, not because he doubted the work of the chemist, but because a natural gas, before it emerged at the surface—like the average story which started as a simple statement—grew and added to itself other gases by the way. It was only necessary to look at some of the analyses to wonder for a moment whether one was really dealing with an ordinary natural gas of the petroleum type, or a gas that had been mixed, like a river obtaining its materials from different tributaries—on the way. Nitrogen might be taken as one constituent. If it were possible to be quite certain that the nitrogen in a natural gas really indicated the nitrogen content of the oil from which it was derived, one would begin to think, with the author, of the great significance of nitrogen in the seepage gases ;

but natural gases were obtained with percentages of nitrogen, even up to 80. The well-known Dexter gas in Kansas, noted for its high percentage of helium, contained nearly 83 per cent. of nitrogen. Then again, some of the gases of Texas contained between 35 and 40 per cent. of nitrogen, which is obviously in excess of the nitrogen in oils from the same fields. The author had given several short ways of settling questions on which those who were geologists must have spent a great deal of time and money; he was able to detect from simple analyses whether samples had come from a faulted zone, and had offered another paper on that question which would contain fuller details. It was of the very greatest practical importance if one could in any field find out from the nature of the oils being obtained whether the ground was faulted or not. The decision and precision of the author's conclusions tempted him to ask now for a certain amount more information. For instance, the author said that in those Mexican oils which were associated with salt dolomite domes, the sulphur content varied according to the amount of dolomite available in the reservoir, and in referring to those reservoirs he said that, "in those places where the thickness of the dolomite was appreciable and where the sulphur content of the same is correspondingly large by bulk, sulphur was absorbed by the oil, resulting in the formation of asphaltum, causing a corresponding increase in the specific gravity of the oil. He also said that "in those places where the dolomite was thin, and, consequently, the bulk of the sulphur present in it small, little change has taken place in the oil itself. It is then seen that in an oil-field containing oils of varying gravities and properties the variations were directly traceable to local geological conditions." Looking at the five illustrations quoted, one would like to know what the result would be if there were more of them. He should like to know whether the correspondence between the thickness of the dolomite and the amount of asphaltum and sulphur in the oil was supported by further examples, because everybody must know that there must be to some extent an accidental relationship between the two. We could not expect a strict and constant ratio between the thickness of the dolomite bed and its sulphur content. Any geologist could give half a dozen other ways in which accidents might occur to interrupt the uniformity of that law. Later on the author seemed to show that no such secondary absorption of sulphur was necessary at all, because in quoting the composition of *Macrocystis*, the postulated source, he said that it contained sulphur enough in itself to account for all the sulphur in the Mexican oil. He went on to say: "There seems to be little doubt from the above figures that the asphalt was formed contemporaneously with the oil, and that all the sulphur compounds present in the oil are indeed integral

parts of the oil." Had he detected here an inconsistency in the paper? Did not the author say in one place that the quantity of sulphur in the oil was dependent on the thickness of the dolomite reservoir, and in another place that the oil had sulphur in its composition as part of its original sin? As the paper was read, it gave him the impression that there was an inconsistency between the two statements. One knew, of course, that dolomite, gypsum, salt and oil were constant companions, nearly always being found together, and in many fields where the oil was markedly deficient in sulphur. He was therefore inclined to ask for a good deal more evidence before accepting the rule that the thickness of dolomite corresponded to the amount of sulphur in the oil itself, a rule one would accept almost with joy, if true. In the same way, with regard to gases he should have liked to see a larger number of gas analyses quoted, especially with regard to the nitrogen, because he felt that a great deal of the meteoric water that went down carrying nitrogen in solution affected the composition of the gases afterwards brought to the surface mixed with petroleum gases, in quantities sufficient to make them the predominant partner of the mixture. He had only raised those points in the hope that the author might be able to give some information about them. He felt that the paper that had been read was one that members could not effectually discuss at once, but was a paper which should be read carefully and thought over first.

Mr. Lessing said that very much more work would have to be done before the author's hypothesis could be properly assimilated. He thought the most remarkable feature of the paper was that the author showed there was no one particular origin of petroleum. Oil had been formed from the geological deposits which happened to be in one particular spot, which of necessity must differ in one region from another. The author had gone back to the evidence to be obtained from the original raw material from which the oil was likely to have been formed. That line of investigation was one recently adopted by a number of workers in this country, who had made it their business to investigate the origin of coal, and from that point of view he ventured to suggest that the two problems were closely allied. He was very pleased to see that the author had paid great attention to the ash of the oil. The ash of oil was so minute in quantity that it usually escaped the investigation even of very careful chemists. If, on the other hand, it was possible to glean more information on the inorganic constituents of the oil, and compare that with the inorganic constituents of the plant or animal matter from which it was likely to have been obtained in the first instance, taking into account the alteration which the mineral constituents had gone through in the course of being deposited in or removed from the oil, then it might be

posaible the author's theories would be very much more strengthened. With regard to the morphological character of the original raw material, unfortunately in the case of oil things were very much worse off than in the case of coal, because microscopical information was not available. The oil had been exuded and homogenised. One thing he wished to suggest was the possibility of bacteriological action in the decomposition of the original raw material and the formation of oil. The question of gas was a very important one, and not too much reliance should be placed on gases collected on the surface. Ordinary coal gas from a comparatively nitrogenous substance, coal, only contained about 1 per cent. to 1½ per cent. of the nitrogen which was originally present in the coal. Unless the substances from which the oil was made were very highly nitrogenous and hardly carbonaceous, such quantities as those quoted were not very likely.

Dr. J. A. L. Henderson said that it was extremely difficult to attempt to discuss such a paper when it had been so rapidly presented, and in the absence of adequate previous opportunity for its perusal. It struck him that the author really wished to put forward his views tentatively as a matter of interest to the Institution, which would be followed up and thus lead to valuable results. As the paper stood, however, it appeared that some of the author's conclusions would have to be supported by very much more widespread and detailed work in the field and laboratory. The paper leaves the impression of immature generalisation and assertion ; but although many of the facts presented are not new, the treatment is ingenious.

The oils and gases which are found within the Paleozoic rocks, covering an enormous time-range, and characterised, so far as they are known, by their paraffin base, as compared with the oils in the younger sediments of relatively small time-range, with different chemical characteristics, warrant a much closer investigation than appears to have been accorded them. It is to be presumed that during the long Paleozoic period, at least an equal, if not much greater, quantity and variety of animal and vegetable life, and variety of physical and chemical conditions capable of affecting the composition of the oil prevailed, as during the subsequent and shorter period.

The nature of the material from seepages such as occur in England and throughout the world, has always served as a good guide in the past as to the general character of the relative oil to be expected *in situ*, and the present paper deals with an interesting elaboration of this type of investigation.

In attempting to prepare a simple scientific classification of bitumens the author is to be congratulated, and although some of the nomenclature may be called into question—for instance, the advisa-

bility of using the word "Petrolite"—it is a step in the right direction towards much-needed standardisation of terms. Careful treatment of this subject is, however, desirable, and the cordial co-operation of American petroleum technologists in particular must be secured, if a useful result is to be achieved.

Dr. W. R. Ormandy said he regarded the whole matter from the standpoint of the chemist, and would say that if the author had given nothing more than the systematised outline of the subject of the asphaltic bodies he would have deserved very well of the Institution. Those chemists who received occasionally asphaltic bodies for examination realised what a hopeless sort of proposition they had been up against. Nobody knew the nomenclature; the same thing was called by half a dozen names in half a dozen countries. It was, indeed, certain that the views the author had put forward could not by any means be considered as adequately sustained by the amount of information he had given. He joined in the hope of the Vice-President, that the author would give a paper at an early date putting forward further supporting views. He believed that the author had worked out methods for chemical examination of asphaltic bodies and oils, which were the result of a vast amount of labour and time, and it was valuable that he had promsied to put those methods forward.

Mr. Gordon Pitt said there was much in the paper about which he would like to join issue with the author. The implied promise the author had given of going further into the subject and standing up again for criticism, if necessary, was a very attractive proposition. At the same time, the author's own statement of the object of the paper was: "I will attempt to show you this evening the various reasons and results on the path I followed in my examination of England as an oil-bearing country," and this he had done. It was a historical fact that two years or so before the first oil-well was started in England the author did predict, and, as it turned out, accurately predict, the kind of oil that would be got out of it. The author was right, and, therefore, there must be something in his hypotheses and theories, however incompletely they might have been put forward that evening, and however incompletely they might have been backed up by unquestioned fact.

Mr. Redgrove congratulated the author on the scheme which he had put forward for the analysis of the petrolites. The author had put forward a theory which had to be proved to the utmost, but it was only theories that would stimulate experimental research.

Mr. Hackford, in reply, said he would firstly confirm Mr. Pitt's statement that the object of the paper was to show the path he

had followed in obtaining certain results. He had formulated various theories in times past, and had proved their utility in practice by the truth of the predictions made from the analyses of the seepages.

With regard to the scheme of the nomenclature, that was in itself a subject matter for more than one paper. The paper he had read that evening was intended to be supported by further evidence and figures which he had, and which he was prepared to show in sections, in connection with the various points which had been raised. It was a matter that had far-reaching results, for it was well known that seepages themselves had been derived from oils, and, therefore, if the chemical analysis of them was correct, it was possible to know the class of oil beneath; consequently, it had a very great bearing on the subject of oil in general. Another point which was raised by Sir Thomas Holland was the question of the various formations in which the oil occurred. It was a truism to say that the oils varied with the local geological conditions. It was the same oil once upon a time, and if it had altered it was due to some cause, and that cause was the geological condition. If an oxidised oil were found in the middle of a non-oxidised or non-asphaltic oil-field and the sample had oxy-asphaltic bodies in it, then one would know that some particular influence had intervened. The fact that oxy-asphaltic oil was found in a field that so far had only given non-asphaltic oil, showed that there was a fault there. If there was sulphur in irregular masses in a small area it was possible to say, from analyses of the seepages, that that was not the same mother-oil as that which would be obtained in a district where there were large quantities of oil on a gentle anticline extending for miles. Chemical analysis proved that there was a difference in the oils underneath; it was an interpretation of those results that he had wished to bring forward that evening.

With regard to gases, it was true that nitrogen might be met in many ways and hydrogen might get in, but the fact remained that gases from wells producing oils of aromatic content did not contain hydrogen, whereas the gases from wells producing oils of naphthenic content did contain hydrogen.

Supposing a gas was evolved containing 6 per cent. of sulphuretted hydrogen one would know at once that it was obtained from an oil that contained large quantities of sulphur, whereas if it was an oil containing 94 per cent. or 97 per cent. of methane, and practically nothing else, one could have no hesitation in saying that the gas was evolved from an oxy-aliphatic oil.

With regard to the ash in Mexican oil, naturally it was necessary to have a theory in trying to prove the main contention that the seepages were derived from the oils, and that if there was any

impurity in the ash of the seepage the same impurity was in the ash of the oil.

Dr. Lessing had spoken of the different origins of oil, and he agreed with him on that subject. One could not assume that oil was formed from any one material anywhere. It was due to the local geological conditions both now and in the past, and what happened in the past decided the nature of the oil that was produced to-day.

The President, in proposing a hearty vote of thanks to the author for his paper, expressed also the thanks of the Council, and hoped that it was an indication that at an early date some of the other papers the author had promised would be brought forward.

The motion was carried unanimously, and the meeting then terminated.

Note on Solubility of Benzene in Weak Alcohol.

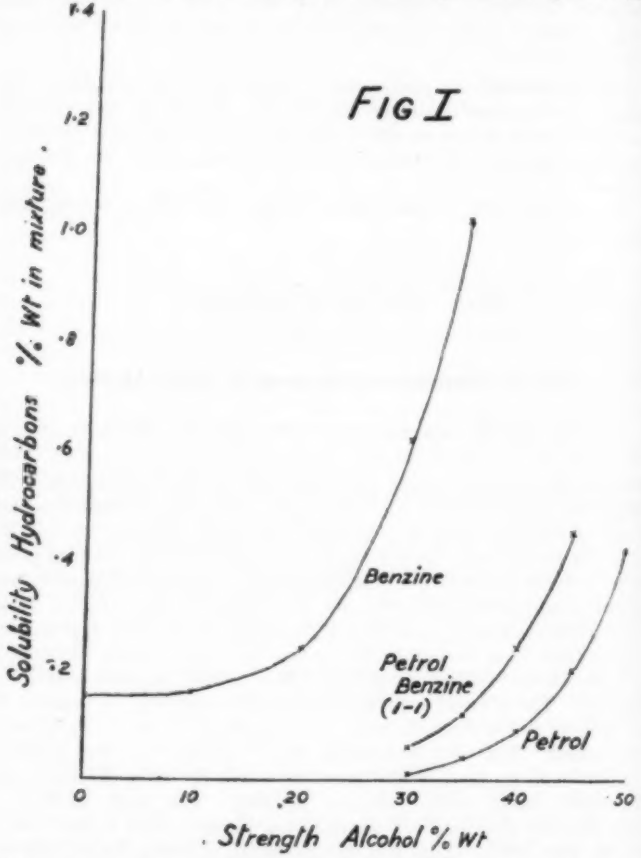
By W. R. Ormandy and E. C. Craven, *Members.*

In a previous paper we discussed the solubility of various aromatic bodies in aqueous alcohol.* The figures were not extended to the lower strengths of alcohol in which the hydrocarbons are soluble to a less extent than 10 per cent. by weight. From the fuel point of view these lower limits of solubility are not of great importance, as one would not consider the use of a highly-hydrated fuel. From the Excise standpoint, however, the question is of more importance, seeing that it is necessary to ensure that by a mere dilution, a potable alcohol cannot be prepared from a fuel mixture containing alcohol. The present note deals with the solubility of benzene in alcohols of lower strength than were employed in the work already mentioned. The determinations were carried out by methods similar to those used in the previous work, the only change found necessary being more effective stirring. The best method is undoubtedly shaking, but as this was inconvenient a mechanical stirrer was tried. This was unsuccessful, it being found difficult to arrange the burettes without fouling the stirrer. Eventually it was found that a disc of perforated zinc attached to the bottom of the thermometer made a very effective stirrer.

---

*Journal, December, 1921.

The next difficulty was in determining the point at which turbidity occurred, this being very feeble. Eventually readings were taken at the point where faint turbidity was distinctly visible and at the point where the liquid became quite clear. The mean of the readings was taken as being the true equilibrium point. The



differences became greater with decreasing alcohol strength. Determinations were made down to about 20 per cent. alcohol strength. For the solubility in water we have accepted Moore and Roaf's figures (Proc. Royal Soc., 1905 (*b*), 77, 96) in the case of benzene. In the case of petrol A a rough determination was made.

The collected figures read from the smoothed curves are given in the table below :—

Strength Alcohol. % wt.	Benzene.			Petrol A.	Petrol-Benzene.
	0° C.	15° C.	30° C.	15° C.	15° C.
0	0·08	0·13	—	0·004	—
5	0·08	0·15	—	—	—
10	0·10	0·16	—	—	—
15	0·13	0·19	—	—	—
20	0·16	0·24	—	—	—
25	0·24	0·38	—	—	—
30	0·38	0·62	1·32	0·01	0·06
35	0·62	1·02	1·88	0·04	0·12
40	1·14	1·80	2·64	0·09	0·24
45	1·80	3·00	—	0·20	0·45
50	—	—	—	0·42	—

The figures give the per cent. by weight of hydrocarbons in the equilibrium mixtures. The superior solubility of benzene will be noticed as compared with petrol spirit, although the latter is the A petrol as used by Mr. Ricardo in his recent work, and therefore contains considerable amounts of aromatic hydrocarbons.†

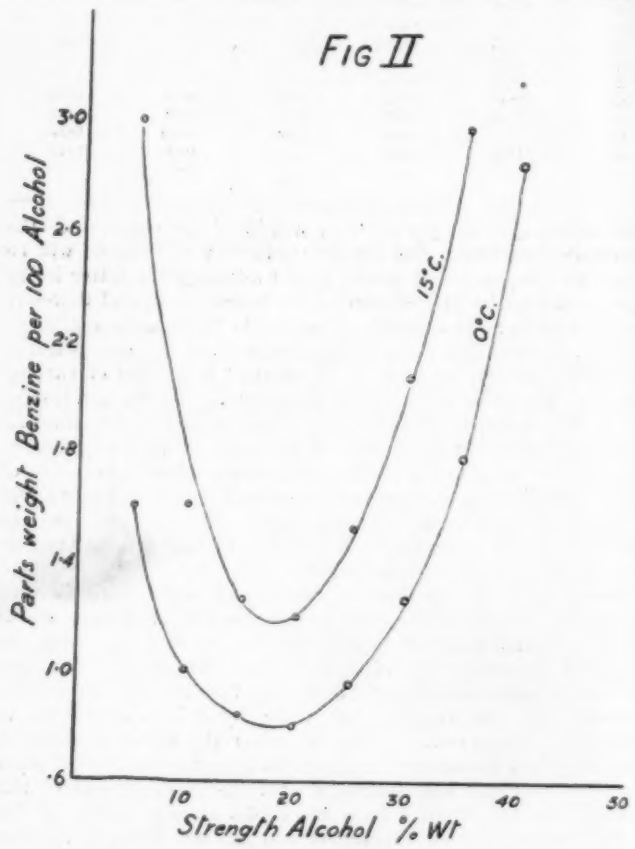
In Fig. I. are shown the solubility at 15° C. of benzene, petrol A and petrol—benzene mixture (1 : 1 volume) in alcohol of varying strength. The great reduction in the solubility on the addition of petrol will be noticed. It follows from these figures that on diluting an alcohol containing benzene to 35 per cent. strength at ordinary temperatures the aqueous alcohol will contain about 1 per cent. of benzene, and this can be reduced to below 0·12 per cent. by extracting with a small proportion of petrol spirit. The 0·12 per cent. of hydrocarbons left in cannot be detected by tasting, so that benzene alone is rather poor as a denaturant.

Putting aside the question of the use of petrol spirit it is of interest to consider what is the largest amount of benzene which can be separated from an alcohol mixture by dilution. Suppose 100 parts by weight of alcohol to be taken and a few per cent. of benzene added. Further, let the alcohol be diluted n times, *i.e.*, the original 100 parts by weight be diluted to $100\,n$ parts with water. n May be called the factor of dilution. The strength of the diluted alcohol will then, of course, be $100\,n$ per cent. by weight. The solubility of benzene in alcohol of this strength can be obtained from the tables already given. If this $= S$ per cent. the total amount of benzene remaining in solution in the diluted alcohol $= S \times 100n$.

† For the composition and other data relating to this petrol spirit see Ricardo, *The Automobile Engineer*, March, 1921.

Calculating this quantity for various degrees of dilution we get the following figures :—

Strength of Alcohol	45%	40%	35%	30%	25%	20%	15%	10%	5%
Factor of dilution ..	2·22	2·50	2·86	3·33	4·00	5·00	6·67	10	20
$S \times 100n$— 0° C. ..	4·00	2·85	1·78	1·27	0·96	0·80	0·84	1·00	1·60
15° C. ..	6·66	4·50	2·97	2·07	1·52	1·20	1·26	1·60	3·00



Plotting these results in the form of curves we get Fig. II. It will be seen that the minima of the two curves occurs at the same dilution of alcohol, namely, about 17½ per cent. wt. strength, corres-

ponding to dilution factor of about 5·8. In volumes this would be 1 vol. alcohol diluted with 4½ vols. water. It follows that in order to remove the maximum quantity of benzene from an alcohol-benzene mixture the alcohol must be diluted to the extent mentioned. At ordinary temperatures, however, about 1 part of benzene per 100 parts alcohol must always be left in the diluted spirit. Probably this amount of benzene would be considered to be nauseous. If distillation of the diluted spirit were resorted to, however, this last portion of benzene could easily be removed as the well-known ternary mixture boiling at 65° C. and containing 74 per cent. of benzene.

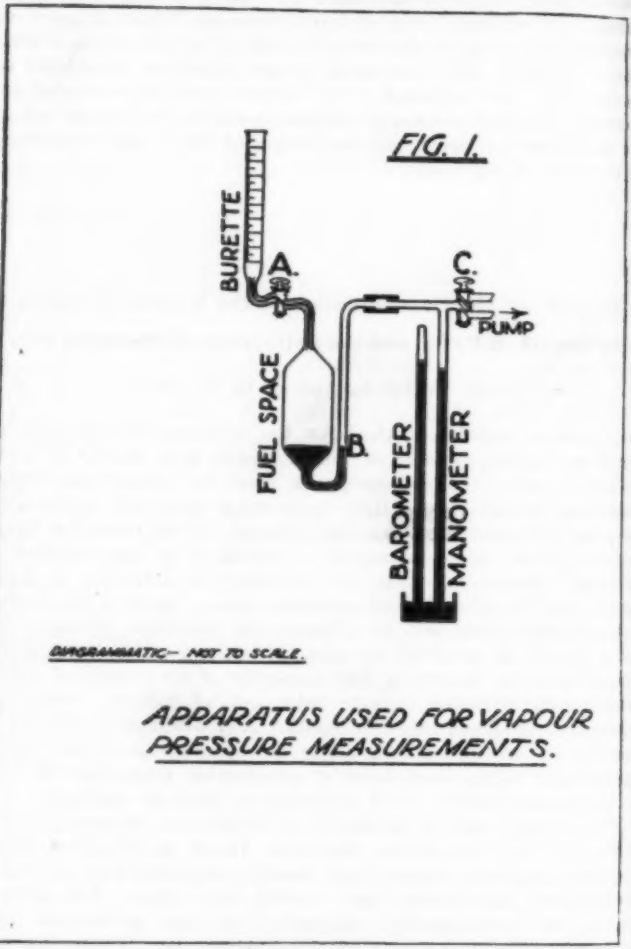
A Method for the Determination of the Vapour Pressure of Hydrocarbon Fuels, and the Estimation of Dissolved Air.

By H. T. Tizard and A. G. Marshall.

To devise a suitable method for the accurate measurement of the true vapour pressure of mixed liquids is a matter of some difficulty, since the measurements must be carried out under conditions which ensure that evaporation does not appreciably alter the composition of the liquid phase. In the case of a liquid such as petrol, which is usually a mixture of a large number of different substances, it is not sufficient to introduce a large quantity of it into a closed evacuated space—such as the top of a barometer tube—and to measure the resultant pressure, for the presence of dissolved air may introduce a considerable error. Petrol dissolves something like a quarter of its volume of air at atmospheric pressure, which comes out of solution when the liquid is introduced into a vacuum. Any attempt to get rid of this air by previous boiling alters the composition of the liquid, particularly when it contains a considerable proportion of low-boiling hydrocarbons, or of hydrocarbon gases in solution.

The method recently published by Wilson and Barnard (*Journal of the Society of Automotive Engineers*, Vol. 9, p. 313, Nov., 1921) involves previous boiling, and closely resembles one on which preliminary experiments were carried out by us. The method which we subsequently adopted does not necessitate any treatment of the liquid, other than drying it; it also has the advantage of not requiring the employment of a high vacuum. It was devised and used by us during the course of a research on fuels for internal combustion engines, which was carried out

in 1919 in conjunction with Messrs. Ricardo and Company for The Asiatic Petroleum Company. We are much indebted to the latter company for permission to publish the details.



APPARATUS USED FOR VAPOUR PRESSURE MEASUREMENTS.

The apparatus is shown diagrammatically in Fig. 1. A reservoir of about 100 c.c. capacity is connected at its upper end to a short burette by means of a piece of capillary glass tubing

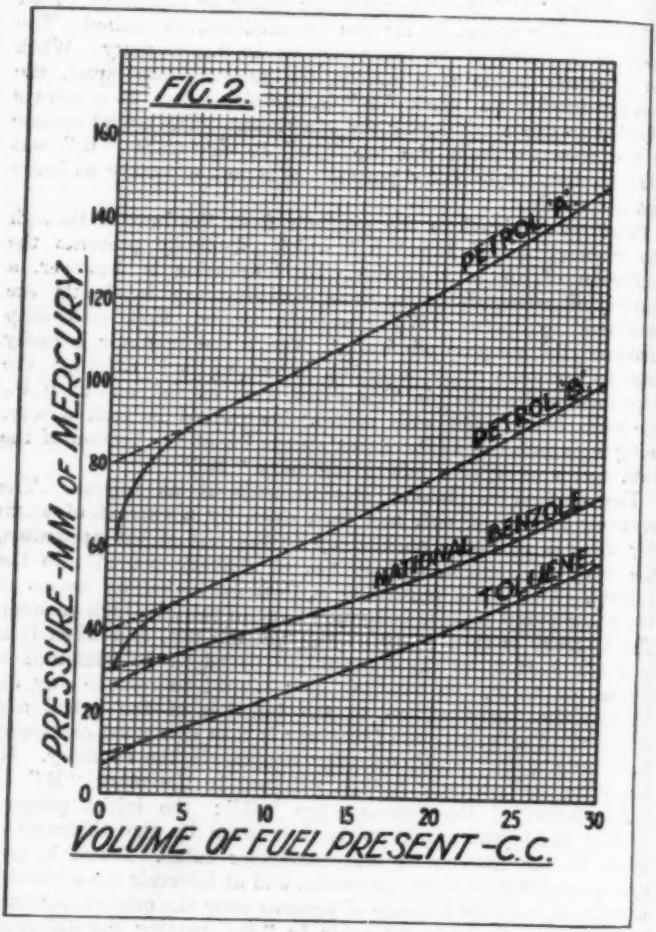
containing the tap "A." At its lower end is sealed on a glass tube which is bent U-shape, and connected to a manometer, etc., by means of a piece of rubber pressure tubing. By means of the two-way tap "C," the apparatus can either be evacuated by an ordinary water pump, or air can be admitted, as desired. The reservoir is sealed at its lower end by 10 c.c. mercury. When the pressures inside and outside the reservoir are equal, the mercury reaches the mark "B" in the side tube. It is always adjusted to this mark during the experiment. The actual volume of the reservoir from the tap "A" to the mark "B" was 109 c.c., but for ordinary purposes it is not necessary to know this accurately.

Petrol is admitted to the reservoir from the burette through the mercury sealed tap "A," which effectively prevents the admission of air from outside. Its lubrication is, however, a matter of some difficulty, since ordinary tap lubricants are dissolved by petrol. We eventually found that soft soap answered the purpose admirably. The whole reservoir is easily kept at constant temperature by immersing it in a bath; the experiments described in this paper were carried out at 0° C., the bath being filled with melting ice packed in such a way, using wire gauze, that there was always ice at the bottom of the bath and a clear view left of the mark "B."

The method of taking measurements is as follows. The reservoir is cleaned out, and then dried by a current of warm dry air. It is then connected up to the rest of the apparatus, the tap "A" closed, and 10 c.c. of mercury poured into the burette. The whole apparatus is then evacuated by means of the water pump, no care being necessary to obtain a high vacuum. The mercury is then admitted through the tap, and when it is near the bottom of the burette the petrol to be examined is poured on to it, the burette being tapped to remove any air bubbles that may adhere to the junction of the petrol and mercury. The admission of mercury is then continued cautiously until only a very small quantity remains in the capillary. Its height in the reservoir is then adjusted to the mark "B" by maniuplation of the two-way tap "C"; the initial pressure (of air) inside the apparatus is then given by the difference of levels in the manometer and barometer tubes. Petrol is now slowly admitted in small quantities, and at intervals the admission is stopped, and the increase of pressure over the original obtained by adjusting the mercury again to "B," reading the difference of level of the manometer and barometer tubes, and subtracting from this the original pressure in the apparatus.

Typical curves showing the variation of increase of pressure (p^1) with volume admitted, are given in Fig. 2. It will be noticed

that for the ordinary mixed petrol, the apparent "vapour pressure" first rises quickly as the volume admitted is increased, and then more slowly after the volume reaches 5 to 10 c.c. of



liquid. When the volume admitted is greater than 10 c.c. (or 1-10th of the volume of the reservoir) it may be assumed without appreciable error in all ordinary cases that evaporation does not change the composition of the liquid. The increase

in p^1 on further addition of liquid is caused by the compression of the air in the apparatus, by a certain amount of dissolved air coming out of solution, and by the hydrostatic pressure due to the height of liquid petrol standing above the mercury in the closed space. All these effects are eliminated by extrapolating this part of the curve to the line of zero volume in the manner shown by the dotted lines in Fig. 2, and the value so obtained represents the true vapour pressure of the mixed liquid at the temperature of the experiment, *i.e.* the vapour pressure measured under such conditions that evaporation does not alter the composition of the liquid. The graphical extrapolation is probably correct to 1 m.m.; the accuracy of the method could undoubtedly be improved considerably if required, but a possible error of 1 m.m. is not of much importance in connection with internal combustion engines.

It is necessary to dry the liquid before admitting to the apparatus, for if petrol is saturated with water, the partial vapour pressure of the latter will be equal to that of pure water, which at 0° C. is 4·6 m.m. The measured vapour pressure of the wet liquid may therefore be considerably higher than that of the dry liquid, in spite of the very small solubility of water.

The fact is often overlooked that the true vapour pressure of petrol may not be a reliable criterion of its value for engine "starting" purposes. This will easily be seen from the following considerations. The correct mixture for complete combustion of petrol contains about 1 part of petrol to 15 of air by weight; this corresponds to 1 c.c. of liquid petrol to about 8000 c.c. of air measured at N.T.P. When an engine is running idly, the mixture delivered to the cylinders is certainly much richer than this, but even if it were eight times as rich we should only have 0·1 c.c. of petrol to 100 c.c. of air, and the actual pressure of hydrocarbon vapour in the air may in such a case be very considerably less than the true vapour pressure, as the curves in Fig. 2 show. It will be seen that the curves corresponding to "petrol B" and National Benzole are tending to cross when only very small quantities of liquid are admitted to the reservoir, so that the actual pressure exerted when only 0·1 c.c. of liquid are admitted is probably less for the "B" than it is for the Benzole. Hence, the latter will be just as good, if not better, for starting purposes, even though its true vapour pressure is 10 m.m. lower. The less homogeneous a liquid is, the more pronounced will be the fall in apparent vapour pressure when only small quantities of the liquid are present. If the liquid is quite pure, there is of course no corresponding fall; the curve for nearly pure toluene only shows a very slight fall, so that the vapour pressure exerted when only very small quantities of the

liquid were admitted, is very nearly equal to the true vapour pressure. If the variation of vapour pressure with volume admitted is followed out in the manner described above, far more reliable information can be obtained as to the qualities of liquid fuels for internal combustion engines than from a single measurement of the true vapour pressure when the proportion of liquid volume to gaseous space is large. A single measurement of this kind may indeed give very misleading results unless the range of boiling of the liquid is also taken into account.

The slope of the curves obtained after the volume of liquid admitted is sufficiently large for evaporation not to alter its composition appreciably, depends mainly on two factors—(*a*) the initial pressure of air in the apparatus, (*b*) the solubility of air in the liquid. Naturally the higher the initial pressure the steeper will be the curve. It is convenient to work with a fairly low initial pressure, since the necessary extrapolation is then easier. The curves shown in Fig. 2 were all taken with the same initial pressure of air in the apparatus, namely, about 7 m.m. It will be observed that the curves corresponding to "petrol A" and "B" are parallel, and steeper than the two lower curves which are also nearly parallel. The reason for this is that the solubility of air in paraffin hydrocarbon is greater than that in aromatic hydrocarbons.

The shape of the curves, when the liquid is present in sufficient quantity to exert its true vapour pressure, can be calculated theoretically as follows:—Suppose the true vapour pressure to be p m.m., and suppose the liquid to contain x c.c. of dissolved air in l c.c. of liquid, x being measured at N.T.P. Suppose, further, that if the liquid is saturated with air at atmospheric pressure and the temperature of the experiment, it would contain y c.c. of air per c.c. of liquid. Then, if it is in equilibrium at any other pressure P of air, the volume of dissolved air (at N.T.P.) per c.c. is $\frac{y \cdot P}{760}$, since the solubility is known to be closely proportional to the pressure if the temperature is constant. Now let the volume of the reservoir be V c.c. and the initial pressure of air before liquid is admitted be P_0 m.m. Admit v c.c. of liquid. Then the *total* quantity of air in the closed space measured at N.T.P. will be:—

$$\frac{P_0 \cdot V}{760} + vx$$

This is present in two forms, (*a*) in solution in the liquid; (*b*) in the gaseous space. If the partial pressure of the air in the gaseous space is now Pv, the amount dissolved in the liquid is $\frac{v \cdot y \, Pv}{760}$, and the amount in the gaseous space of $(V-v)$ c.c. is $\frac{Pv\,(V-v)}{760}$.

Hence :—

$$\frac{P_0V}{760} + vx = \frac{vy\,Pv}{760} + \frac{Pv\,(V - v)}{760}$$

$$\text{or} \qquad Pv = \frac{P_0V + 760\,vx}{V - v + vy}$$

Now the *total* pressure measured, if we neglect the hydrostatic pressure of the liquid, is the pressure of the air + the vapour pressure of the liquid, *i.e.*, $Pv + p$. If we subtract the original air pressure P_0, we get the apparent vapour pressure, as shown in Fig. 2, and called p^1 above :—

$$p^1 = Pv + p - P_0 = p + \frac{P_0V + 760vx}{V - v + yv} - P_0$$

$$= p + \frac{760vx + P_0v\,(1 - y)}{V - v(1 - y)}$$

This is the equation to the curve representing change in apparent "vapour pressure" with change in volume of liquid admitted, so long as the liquid is present in such a volume that slight evaporation in the reservoir does not alter its composition appreciably. The effect of the hydrostatic pressure of the liquid can, of course, easily be allowed for if greater accuracy is desired. The following conclusions can be drawn for this equation :—

(1) When v is very small $p^1 - p$, the true vapour pressure. Hence, if the curve is extrapolated it will cut the pressure axis at the point corresponding to the true vapour pressure.

(2) This is true whatever is the value of P_0, the initial pressure of air in the apparatus. The only effect of increasing P_0 is to increase the slope of the curve. This has been tested by experiments in which the initial pressure was varied from 0.1 m.m. to 325 m.m of mercury. The curves so obtained all extrapolated back to the same point on the axis $v = 0$.

(3) The slope of the curve at any point is given by $\frac{dp^1}{dv}$. If v is fairly small compare to V,

$$\frac{dp^1}{dv} = \frac{760x + P_0\,(1 - y)}{V}$$

As v increases, the slope of the curve increases, hence all the curves bend slightly upwards as shown by the experimental results. It is clear from this equation that an increase in either x or P_0, increases the slope of the curve. When P_0 is fairly small, x, *i.e.*, the amount of air in solution, determines the slope. The method can thus be used conveniently to determine the solubility of air in any liquid.

From the results shown in Fig. 2, the actual amount of dissolved air in the petrols "A" and "B" is calculated to be 0.22 c.c. per c.c. of liquid, and about 0.15 c.c. per c.c. of benzole.

When Oil is "Good." ?[1]

By William F. Parish.[2]

A petroleum product is good or poor only as it suits, or does not suit, the condition for which it is used. A watch oil may be exactly right for a watch; it will lubricate for years without evaporation, it will not gum and will not cause pitting of the fine polished parts. It is perfect for the purpose for which it is made. However, if this watch oil was put into the cylinders of a steam engine, it would fail to lubricate, and would immediately become a "poor oil," not through any loss of intrinsic value, for it is still the 100 per cent. watch oil, but through the fact that it was not being used under conditions suitable to its nature.

Conversely, citing an example of a perfect steam cylinder oil, giving satisfactory performance in conjunction with the water carried over in the steam coating, the valves and cylinder walls with a thin but sufficient film of oil, allowing lubrication to be carried on with a very small amount of oil, and even though a considerable amount of this oil accumulates in the boiler, it does not cause trouble. This can be called a 100 per cent. steam cylinder oil. If a few drops of this same oil would be put on the delicate mechanism of a watch, the watch would stop, and the oil would then be graded "very poor." A spindle oil can be almost perfect for the reservoir of a fast-running cotton spindle, while the same oil used on a stone crusher would cause damaged bearings and put the machine out of action, due to it being a "poor oil." The oil entirely suitable for the heavy stone crusher would stop the cotton spindle, and in consequence would earn the term "poor oil." A very fine fuel to be burned under furnaces, and giving the best of satisfaction as a steam producer, would cause great trouble in the bearings of the mill. Conversely, the oil used in the mill bearings would not always give the same satisfaction under the boilers as the fuel intended for that purpose, which is proof that the money expended in producing and refining an oil means nothing to the well-working of the product, if it is placed outside of its useful field of action.

---

[1] To be read before the March meeting of Chicago members of the American Society of Lubrication Engineers, March 3, 1922.

[2] Member, Consulting Lubrication Engineer, Chicago, Ill.

Kerosene is good for lamps when the lamps burn brightly and do not smoke. If the kerosene was made better, in that more money was spent on its production, and it smoked and did not burn brightly, it would be a poor burning-oil and not worth the price paid for it. With fuels the 72 Baume gravity gasoline in use when the automobile industry was young and when fuel was plentiful, was a good fuel because it was entirely consumed in the engines that were especially adapted for a fuel of that light volatile nature. While the engines were continued, the fuels became heavier and not as suitable for the engines, and the term "poor fuel" was given them. As a matter of fact, the present fuel is much better in many respects than the old lighter fuel, except for the basic fact that it is not as suitable for the engines in which it is used. This is not the fault of the fuel as such, but rather the fault of the engine.

The present motor lubricants are passing through a very trying period. They are being made with more care and at greater expense than ever before, and yet there is a general opinion on the part of the motoring public that something is wrong with the oils. The general complaint is that they become very thin after a short time in the engine, and that the use of the oils produces much carbon in the cylinders, necessitating more frequent cleaning. The lubricating oil is taking the blame for the unbalanced condition of the engine and the fuel. If the fuel was suitable for the engine (which authorities seem to agree it is not), then our motor oils would be much cheaper and more suitable for the engine. The fuel being "poor," which means that it is no longer adapted to the engine, has brought forth a series of events that make it necessary to do many things unthought of when the industry was new and the fuel was "good." The matter of removing carbon from engines in the days of not longer than ten years ago, was never considered serious. To-day, carbon must be removed every two to five thousand miles, and under some conditions the evil effects of carbon are noticed much sooner. Carbon causes wear and loss of power by stopping the action of the piston rings in their grooves. Carbon causes preignition and pounding, and the consequent straining of bearings and parts. If carbon could be eliminated, the entire motoring public would be greatly relieved, and would undoubtedly run up greater mileage in consequence. There is no question but that troubles in operation, such as excessive carbon, traceable directly to the present unbalanced condition of the engine, fuel and lubricant, have brought a considerable reduction in the use of cars.

The wear in the cylinders has introduced an entirely new and profitable industry, engaged in the re-grinding of cylinders and the fitting of over-sized pistons, estimated as affecting at least one million cars per year. The piston ring manufacturers have extended their operations until rings are one of the easily obtained

articles of commerce. This is due to the attempt of the motor owner to prevent some of the more noticeable conditions due to the engine and fuel being no longer in balance.

Why should the automobile engine require a new set of rings every season, as is becoming the practice? Steam engines will operate on the same set of piston rings for years, it being an exceptional condition when the rings have to be renewed. The steam engine and its lubricating oil have never been out of balance. Lubrication of the steam cylinder is nearly perfect, and as a consequence the rings wear but little. The steam cylinder oils are "good oils" because they can perform good and useful service in preventing wear and replacements. If all the boiler feed-water in the world would change in nature to an extent that the lubrication of the cylinders and valves of the steam engines would suddenly become impossible, the classification of steam cylinder oils would change from "good" to "bad," as soon as the trouble would make itself felt.

Lubricating oil is used for the purpose of preventing friction and wear. A good oil is one that will prevent the most friction and wear. When wear takes place, or when there is so much friction in the moving parts that the speed or power is affected, then the oil is not doing its work. If the wrong oil for the work is being used, then it is "poor" oil for that particular machine. The fact that it may be a most excellent lubricant for several other uses, will make but little impression on the owner, his machine being overloaded and is wearing out. If a cheaper oil, in that it is not as expensive to make and buy, will allow the machine that is wearing out to be saved, then the cheap oil becomes a valuable article and is raised immediately to the "good" oil classification. Good oils are therefore suitable oils; poor oils are those that are not suitable. When an engine is being operated under conditions that are changing in such a way as to affect the lubricant, a "good" oil can become a "poor" oil as these conditions affect it.

In the case of the present engines of our tractors, trucks and cars, the fuel is not being entirely disposed of by the engine, a considerable part of it being too heavy to be burned. Therefore, it does not volatilize and does not enter the engine as a gas, but a large portion of it actually drains into the engine in its original fluid state. Some of this liquid is finding its way to the crankcase, and is combining with the lubricating oil. This brings about what is now known as the Dilution Problem.

Dilution of the lubricating oil is so rapid in the winter that the original character of the oil is entirely lost after a few hours working in the crankcase. The fuel that escapes to the crankcase, and there combines with the lubricant, thins down the lubricant until it resembles kerosene more than it does lubricating oil. In this way

the very finest and most expensive of motor oils will change so rapidly in the engines, that all the original characteristics of the lubricant are lost, and the mixture that remains is neither a "good" fuel nor a "good" lubricant, but is a "poor" mixture, which is discarded after it has done all possible damage to the engine.

The very fact that these mixtures are taking place is evidence of the unbalanced condition of the engine and the fuel, which is ruining "good" lubricants and making "poor" lubricants of them. When the engines were using the more volatile fuels, which were in consequence entirely consumed, there was no condition of the thinning out of the oil as we have to-day. It required less oil to lubricate a motor per thousand miles, and the oil was a better motor lubricant to start with because it was made for the engine, and not to combat the dilution problem, as is necessary with the present-day lubricants. All motor oils are now made very thick and heavy, so when they are put in the engine, and are contaminated by the fuel, they will nevertheless retain some of their body and do part of the work for which they were intended. The motor oils of the old days were made of the best of the neutrals, and these oils were particularly adapted to the mechanical needs of the engines. To-day the same oils are used mainly by Eastern oil manufacturers in producing motor lubricants. The heavy steam cylinder oils are carbon producers when used in the internal combustion engine. Most carbonization trouble is the result of using these heavy oils, and these heavy oils are necessary because the heavy and only partially volatile fuel ("poor" fuel), makes the use of the former suitable and good lubricants impossible.

There are several solutions to the present unfortunate condition of engine, fuel and lubricant. The petroleum industry seems to have reached the limit in regard to the volatility of fuel. Authorities agree that fuel will be less volatile as time goes on, until we find a fuel other than of petroleum origin. The leading engineers of the automotive industry state that they have about reached the limit of development of the present engine. They cannot utilise more of the present fuel than they are doing and they do not see how it will be possible to use as much, if the fuel is made heavier. One solution is to give up the present engine and build something else. This means going to the steam engine or turbine, the electrically-propelled vehicle, or to some other type of internal-combustion engine. Accepting any of these suggestions to change the design of the present engine would mean the expenditure of billions of dollars. The ten million engines now in use cannot be changed over. No one has offered any solution, beyond the experimental stage, and there are many objectionable features to those that have been offered; conditions of operation may be as serious as the present condition due to the unbalanced engine and fuel.

For instance, with the steam engine the boiler upkeep is affected by the nature of the water, and also by the lubricant used in the engine. It is necessary to have steam systems that are continuous, the water being condensed and used over again. As the steam cylinder must be lubricated, part of the oil gets into this circulating system and causes damage to the boiler. The incrustations from the water also cause damage. With the Diesel and the constant pressure types of the internal combustion engine, the great economy of engines of this type requires that they operate on full load the greater part of the time. When the load is variable the efficiency drops. They are not flexible enough, and must be built very heavy. The electrically-propelled vehicle has well-known limitations as built at present, mostly due to the natural limitations of the storage battery. When we progress to a point where the electric current can be utilised direct, without the storage battery, we will have a simple means of locomotion. However, that time is in the future, and the transition from what we have, and what we are prepared to build and are building, will take some years and will involve enormous expenditure.

The situation, as far as the internal-combustion engine and the available fuel is concerned, seems to be at a deadlock, where conditions are bound to become even worse before they improve. The only immediate solution of the problem seems to be to treat the mixed lubricating oil and fuel while the engine is in operation, and to return the fuel portion to the cylinders to be consumed, the regenerated lubricating oil to go back to the crankcase.

This process is now being worked out. The apparatus has been perfected to a point where it has been in actual operation and under observation on trucks, tractors and passenger cars, for several years. The results of the use of this apparatus have been that the oil in the engine has been kept at approximately its original body. All the fuel which leaked into the crankcase and has been caught by the lubricant, has been removed, and the recovered fuel has been converted into power in the cylinders, thereby eliminating a double loss. The oil, thinned down by the fuel, has been regenerated and cleaned, and after cooling, has been returned to the crankcase.

The oil in these regenerating systems actually improves with use. The carbon in the engine gradually disappears. The engine remains in its original condition, due to proper lubrication, for much longer periods. Less oil is used per thousand miles, due to the fact that drainings are not necessary with the new system, because they retain their original consistency. These lighter oils are cheaper as a rule, and are more suited to the engine, producing less frictional load and forming less carbon. By returning the lost fuel to the cylinders, it is evident that cars will secure a greater mileage per gallon of fuel.

It may be possible, with the new system of recovering the fuel and regenerating the lubricant, that the present engines can be simplified by having some of the fuel systems taken off. It is also possible that the use of this system will allow the use of even heavier fuels than those we are getting to-day. The engines in the field can be fitted up with the systems, and will then operate as well as the latest engines turned out by the factories. Expensive oils, which are now graded "poor," after they have been in operation for a short time, will remain "good" indefinitely, because the regenerating system affects the necessary balance between the engine, fuel and lubricant.

Current Bibliography

Compiled by W. J. Wilson, A.C.G.I., A.I.C.

Geological.

Baja (Lower) California and Oil Possibilities.—V. H. Wilhelm. *Mining Sci. Press* **123**, 125. *Chem. Abstr.* **15**, 3265.

Geology of the Cement Oil Field, Caddo County, Oklahoma.—F. Reeves. *U.S. Geo. Surv. Bull.* **726**B, 41. *Chem. Abstr.* **15**, 3435.

Oil Prospects in Washington County, Utah. H. Bassler and J. B. Reeside, junior. *U.S. Geol. Surv. Bull* **726**C, 87.

The Migration of Oil. J. von Gal-Scale. *Petr. Times* **7**, 83.

The Geology and Mineral Resources of the Serb-Croat-Slovene State Oil, Asphalt and Paraffin Shales, etc.—*Petr. World* **19**, 49.

Possible Indicators of Oil in Mississippi. *U.S. Geol. Surv. Rept. Petr. World* **19**, 75.

Cedar Creek Anticline. *U.S. Geol. Surv. Rept. Oil Engineering and Finance* **1**, 112.

Is Mississippi to be an Oil State ?—H. D. Easton. *Oil Weekly* **23**, (5), 12.

Petroleum in the Punjab and N.W. Frontier Province. E. H. Pascoe. *Memoirs of the Geological Survey of India* **40**, 331. Geological Survey of India, Calcutta. *Petr. Times* **7**, 187.

Prospect of Discovering Oil in the Province of Antofagasta, Chile.—*U.S. Commerce Rept.*, p. 970.

Mexico : the Future of Its Business.—E. L. Deheny. *Oil, Paint and Drug Reporter, Petr. Section* **100**, (28), 13.

Oil in Mississippi. *Oil Engineering and Finance* **1**, 162.

Petroleum Prospects in New Zealand.—*Petr. Times* **7**, 236.

Les Gisements de Petrole.—J. Chautard.

Geology of Mexico Applied to Oil Finding.—G. Howell. *Oil Engineering and Finance* **1**, 185.

Petroleum Prospects in Columbia.—E. Beck. *Economic Geol.* **16**, (7). *Petr. Times* **7**, 276.

Oil and Gas in Western Canada.—*Petr. World* **19**, 100.

Oil Prospects in Alaska.—A. H. Brooks. *Annual Report of U.S. Geol. Surv. Petr. World* **19**, 108.

The Oil-Producing Sand of Arkansas.—*Oil Engineering and Finance* **1**, 256.

GEOLOGY AND OIL RESOURCES OF COLOMBIA; THE COASTAL PLAIN.—E. Beck. *Economic Geol.* **16**, 457.

NORTHERN ARGENTINE PETROLEUM FIELDS.—G. S. Brady. *U.S. Commerce Rept.*, Oct. 3, 276. *Petr. World* **18**, 495.

THE LOWER ATHABASKA AND SLAVE RIVER DISTRICT.—C. C. Lynch. Canada Dept. of Interior. Nat. Resources Intelligence Branch.

GEOLOGY AND OIL AND GAS PROSPECTS OF CENTRAL AND EASTERN MONTANA.—C. H. Clapp, A. Bevan & G. S. Lambert. *Bull. Univ. Montana, Bureau of Mines and Metallurgy Series, No.* 4.

THE OIL AND GAS PROSPECTS IN THE VICINITY OF BUTTONWILLOW, KERN COUNTY, CALIFORNIA.—R. N. Ferguson. *7th Annual Report of the State Oil and Gas Supervisor.*

SECONDARY INTRUSIVE ORIGIN OF GULF COASTAL PLAIN SALT DOMES.—W. G. Matteson. *Am. Inst. Min. and Met. Eng. Separate No.* 1088. *Min. and Metallurgy, Aug.*, 21. *Separate No.* 1048, *Min and Metallurgy, Feb.* (1921) ,*Separate No.* 1073, *Min. and Metallurgy, May* 23.

OIL POSSIBILITIES OF THE POSTEN SCHOOL STRUCTURE, MONROE COUNTY, ILLINOIS.—L. A. Mylius. *Illinois State Geol. Surv. Press Bull.*

OIL POSSIBILITIES OF REPUBLIC OF HAITI SAID TO BE GOOD.—U.S. Geol. Surv. *Oil Weekly* **23**, 48.

THE DJAMBI OIL FIELD OF SUMATRA.—A. H. Redfield. *Eng. and Min. Jour.* **112**, 939.

THE POSSIBILITIES OF OIL IN EASTERN PENNINGTON COUNTY.—F. Ward. *South Dakota Geol. and Nat. Hist. Survey, Circular No.* 8. *Bull Univ. South Dakota, Series* [21], (7).

ESTUDIO GEOLOGICO DE LA ZONA DE RESERVA DE LA EXPLOTACION NACIONAL DE PETROLEO EN COMODORO RIVIDAVIA (TERRITORIO NACIONAL DEL CHUBUT).—R. Wichmann. *Direccion General de Minas, Geologia e Hidrologia, Boletin* 25, *Ser. B.*

OIL POSSIBILITIES OF MANITOULIN ISLAND.—M. Y. Williams. *Canada Dept. Mines Geol. Surv. Summary Rept.*, 1920, *part D*, 26D.

PALEOZOIC STRATIGRAPHY OF PAGWACHUAN, LOWER KENOGAMI, AND LOWER ALBANY RIVERS. M. Y. Williams. *Canada Dept. Mines Geol. Surv. Summary Rept.*, 1920, *part D*, 18D.

GEOLOGICAL DISTILLATION OF PETROLEUM.—B. Willis. *Am. Inst. Min. and Met. Eng. Separate No.* 1088, *Mining and Metallurgy, Aug., p.* 18. *Section* 10, *Mining and Metallurgy, Jan.* (1920).

NOTES ON ELK HILLS OIL FIELD.—Summary of operations, California oil fields. C. C. Thomas and F. E. Smith. *7th Annual Report of the State Oil and Gas Supervisor, July* 7.

GEOGRAPHICAL.

OIL SHALE AND PETROLEUM PROSPECTS IN BRAZIL.—H. E. Williams. *Eng. Min. J.*, Sept. 25, 1921. *Petr. Times* **7**, 86.

VISCOSITIES AND POUR TESTS OF TYPICAL CRUDE OILS FROM THE EASTERN AND ROCKY MOUNTAIN PRODUCING FIELDS OF THE UNITED STATES.—E. W. Dean, A. D. Bauer & W. B. Lerch. *U.S. Bur. Mines Repts. Investigations*, 2290.

PETROLEUM INDUSTRY IN MEXICO.—*U.S. Commerce Reports*, p. 590.

PETROLEUM INDUSTRY AT BAKU.—*U.S. Commerce Reports*, p. 663.

PETROLEUM LAW FOR ECUADOR.—*U.S. Commerce Reports*, p. 779.

VENEZUELA ROYAL DUTCH AND SHELL INTERESTS.—U.S. Department of Overseas Trade. *Petr. World* **19**, 66.

CANADA: MANITOULIN OIL PROSPECTS.—*Petr. World* **19**, 75.

ARGENTINA AND ITS OIL.—*Petr. World* **19**, 78.

POLAND'S OIL DEPOSITS.—*Petr. World* **19**, 82.

MEXICO OIL PROSPECTS.—G. Howell. *Oil Engineering and Finance* **1**, 12.

GOOSE CREEK FIELDS.—G. Howell. *Oil Engineering and Finance* **1**, 15.

A NEW DISCOVERY.—*Oil Engineering and Finance* **1**, 88.

THE PETROLEUM RESOURCES OF ALASKA.—*Oil Engineering and Finance* **1**, 112.

REPORT ON THE FINANCIAL AND ECONOMIC CONDITIONS OF THE ARGENTINE REPUBLIC.—Commercial Secretary to H.M. Legation at Buenos Ayres. H.M. Stationery Office. *Petr. Times* **7**, 118.

PETROLEUM MATTERS IN FINANCE.—*Petr. Times* **7**, 119.

THE AMERICAN FIELDS DURING 1921.—*Petr. Times* **7**, 131.

THE PETROLEUM REFINING INDUSTRY IN CANADA, 1918.—*J. Soc. Chem. Ind.* **41**, 7R.

MEXICO: THE LAND OF OIL.—Government Report upon Operations during 1921. *Petr. Times* **7**, 184.

CAPITAL IN THE ROUMANIAN PETROLEUM INDUSTRY.—Moniteur du Pétrole Roumain. *Petr. Times* **7**, 190.

PETROLEUM IN WESTERN AUSTRALIA.—*Petr. Times* **7**, 203.

THE PRODUCTION OF THE COMODORO RIVADAVIA OIL FIELDS FOR 1920.—*U.S. Commerce Report*, p. 843.

OIL WELLS IN THE TAMPICO DISTRICT.—*U.S. Commerce Report*, p. 1030.

PETROLEUM CONCESSIONS IN HONDURAS.—*U.S. Commerce Report*, p. 1030.

PETROLEUM COMPANIES OPERATING IN EGYPT.—*U.S. Commerce Report*, p. 1034.

PROPERTIES OF TYPICAL CRUDE OILS FROM THE PRODUCING FIELDS OF NORTHERN AND CENTRAL TEXAS, NORTHERN LOUISIANA AND ARKANSAS.—E. W. Dean, M. B. Cooke & C. R. Bopp. *U.S. Bur. Mines Repts Investigations* 2293.

NORTH ARGENTINE FIELDS ARE RICH.—*Oil Paint and Drug Reporter. Petr. Sec.* **100**, (28), 19.

QUALITY OF CALIFORNIA CRUDE IMPROVING.—*Oil Engineering and Finance*, **1**, 160.

OIL DEVELOPMENTS IN VENEZUELA.—D. A. Sutherland. *Petr. Times* **7**, 213.

UNITED STATES OIL RESERVES.—*Petr. Times* **7**, 221.

OILFIELDS OF PERU.—Production in 1921. *Petr. Times* **7**, 224.

STATE CONTROL OVER THE OIL INDUSTRY IN POLAND.—S. Bartoszevicz. *Petr. Times* **7**, 225.

AMERICAN PETROLEUM INDUSTRY.—Production of Crude Oil in the United States in 1921. *Petr. Times* **7**, 235.

PROGRESS OF ARGENTINE OIL INDUSTRY.—H.M. Legation at Buenos Ayres. *Petr. World* **19**, 99.

TASMANIA: NO LIQUID OIL POSSIBILITIES.—L. Hills. *Petr. World* **19**, 114.

POLISH FINANCE AND OIL.—Polish Economic Bull. *Petr. World* **19**, 122.

SOUTH AMERICAN RESOURCES.—D. White. *Oil Engineering and Finance* **1**, 245.

RESOURCES OF BALKAN AND NEAR EASTERN COUNTRIES.—*U.S. Commerce Reports*, p. 488.

MINING IN CALIFORNIA DURING 1920.—California State Mining Bureau.

AN OIL PRODUCER SINCE 1735.—P. de Chambrier. *Petr. Age* **8**, 17.

FIRST DRILLER AND FIRST IN WEST.—B. V. Ellzey. *Oil Weekly* **23**, 9

THE PETROLEUM INDUSTRY IN MEXICO.—R. H. Flamm. *U.S. Commerce Reports*, Oct. 24, p. 463; Oct. 31, p. 515; Nov. 7, p. 590. *Oildom* **12**, Dec., p. 33. *Eng. and Min. Jour.* **112**, 823.

PETROLEUM IN THE ARGENTINE REPUBLIC.—O. S. Herold. *Am. Inst. Min and Met. Eng.*, separate No. 1088. *Min. and Metallurgy*, August, p. 15. *Min. and Metallurgy*, Feb. (1920), Sec. 12.

BOLIVIA HAS VAST AREA OF POTENTIAL OIL FIELDS.—A. A. Holland. *Oil Trade Jour.* **12**, (12), 21.

OIL POSSIBILITIES IN KENTUCKY.—R. N. Kolm. *Atlantic Connecting Rod* **13**, Nov., 45.

BRITISH ARE ENTRENCHED IN VENEZUELA.—*Oil and Gas Journal* **20**, Dec., 82.

OIL FIELDS OF RUSSIA.—A. B. Thompson. *Am. Inst. Min. and Met. Eng.*, separate No. 1088. *Min. and Metallurgy*, August, 16. Separate No. 1038, *Min. and Metallurgy*, Jan. (1921), 43.

THE MINERAL RESOURCES OF SYRIA.—I. M. Toll. *Eng. and Min. Jour.* **112**, 846.

MAP OF WEST VIRGINIA SHOWING COAL, OIL, GAS, IRON ORE AND LIMESTONE AREAS.—West Virginia Geol. Surv.

DRILLING AND FIELD OPERATIONS.

SUCCESSFUL METHOD OF INTRODUCING MUD FLUID INTO A FLOWING WELL.—H. B. Thomson. Summary of operations, California Oil Fields. 7th Annual Report of the State Oil and Gas Supervisor. *Petr. Times* **7**, 88.

RATE-OF-PRODUCTION CURVE AND ITS APPLICATION TO THE VALUATION OF OIL PROPERTIES. W. W. Cutler. U.S. Bur. Mines. Rpts. Investigations 2285. *Petr. World* **18**, 489.

PETROLEUM PRODUCTION ENGINEERS.—A. W. Ambrose. *Petr. World* **19**, 65.

THE DIAMOND DRILL FOR OILFIELD EXPLOITATION.—*Oil Engineering and Finance* **1**, 89.

TAKING CORES IN WELLS DRILLED BY THE ROTARY SYSTEM.—E. De Golyer. Bull. Am. Assn. of Petroleum Geologists. *Oil Engineering and Finance* **1**, 90.

THE DIAMOND DRILL FOR OILFIELD EXPLOITATION.—G. Howell. *Oil Engineering and Finance* **1**, 109.

COLLAPSIBLE BIT AND CORING DEVICE FOR ROTARY DRILLING.—J. C. Stokes. *Oil Engineering and Finance* **1**, 113.

STANDARDISATION IN OIL SUPPLIES. L. C. Sands. *Oil Engineering and Finance* **1**, 118.

THE DIAMOND DRILL IN OIL PROSPECTING.—*Petr. Times* **7**, 116.

OXY-ACETYLENE WELDING OF OIL-WELL CASING. P. S. Haury. *Petr. Times* **7**, 121.

THE EFFECT OF WATER INVASION IN THE KERN RIVER FIELD.—*Petr. Times* **7**, 129.

MEASURING METER FOR DRILLING WELLS.—R. C. Mason. *Oil Engineering and Finance* **1**, 141.

GASOLINE WASTE IN THE FIELD.—*Oil Engineering and Finance* **1**, 142.

PUSHING OIL PRODUCTION BY GAS.—A. W. Ambrose. *Oil News* **11**, 137.

LOST OIL DEPOSITS.—*Oil Engineering and Finance* **1**, 158.

DEEP WELL DRILLING.—W. H. Jeffery. W. H. Jeffery Company, Toledo, Ohio.

OIL PRODUCTION METHODS IN RUSSIA.—*Petr. Times* **7**, 220.

OVERDRILLING OF OILFIELDS.—*Petr. Times* **7**, 228.

OIL CAMP SANITATION.—C. P. Bowie. U.S. Bur. Mines Repts. Investigations. *Petr. World* **19**, 93.

PROBLEMS OF DEVELOPING OIL RESOURCES.—A. W. Ambrose. *Oil Engineering and Finance* **1**, 247.

DEPLETION AND OIL PROPERTY TAXES.—S. J. Caudill. *Oil and Gas Jour.* **20**, Dec. 9, 92.

A SAFER DERRICK.—E. J. Munger. *Petr. Age.* **8**, Dec., 24.

NEW PUMP USED GEYSER PRINCIPLE TO FLOW WELLS.—*Oil Weekly* **22**, Sept. 17, 54.

AFTER THE HORSE THE MOTOR CAR; AFTER THE WOODEN DERRICK, THE DERRICK OF STEEL.—H. M. Runkle. *Petr. World* (Los Angeles) **6**, 7.

BLASTING DRILLED WELLS TO INCREASE THE FLOW OF WATER.—S. R. Russell. *Du Pont Mag.* **15**, Nov.–Dec., 8.

PETROLEUM PRODUCTION IN MEXICO. W. P. Taylor. *Atlantic Connecting Rod* **13**, Nov., 14.

Patents.

Oil Well Machinery, comprising the Spring-bail Elevator.—W. G. Black. U.S. Pat. 1,397,072.

Well-boring Apparatus.—B. Boykin, Jr. U.S. Pat. 1,398,413.

Pump Barrel.—A. W. Brown. U.S. Pat. 1,396,922.

Fishing Tool.—C. H. Brown. U.S. Pat. 1,399,249.

Gas Casing Head.—W. J. Droppleman. U.S. Pat. 1,398,093.

Pipe Perforator.—G. W. Dunsworth. U.S. Pat. 1,398,320.

Well-Drilling Machine.—L. B. Ekas. U.S. Pat. 1,397,758.

Well-Drill Wrench.—W. H. Ellinger. U.S. Pat. 1,397,044.

Self-Bailing Well Tool.—L. Garrison. U.S. Pat. 1,399,108.

Safety Key for Drilling Rigs.—E. J. Griffith. U.S. Pat. 1,397,864.

Boring Drill.—G. W. Hanson. U.S. Pat. 1,398,551.

Pump.—G. A. Humason & J. A. Burtschel. U.S. Pat. 1,398,967.

Oil Trap.—R. P. Jones. U.S. Pat. 1,397,892.

Sand Settler.—I. A. Karns. U.S. Pat. 1,397,836.

Method and Apparatus for Separating Oil and Gas.—D. G. Lorraine. U.S. Pat. 1,396,860.

Method of Sealing the Walls of Deep Wells.—W. E. Nolan. U.S. Pat. 1,398,563.

Pump.—F. Roberts. U.S. Pat. 1,399,402.

Multiple-bit Underreamer.—A. L. Segelhorst. U.S. Pat. 1,397,114.

Pump.—J. R. Tinney. U.S. Pat. 1,398,450.

Casing-Pulling Apparatus.—J. H. Wilson. U.S. Pat. 1,398,822.

Pipe Lines, Transport and Storage.

Pipe-Line Transportation of Hot Oil.—L. L. Barrett. *Chem. and Met. Eng.* **24**, 1148. *Chem. Abstr.* **15**, 3553.

Further Tests on Concrete Oil-Storage Tanks.—*Concrete* **18**, 110. *Chem. Abstr.* **15**, 3732.

Storage Tanks, Receivers and Reservoirs.—T. W. Carter. *Oil News* **11**, 58.

Pipe-Line Losses.—U.S. Bur. Mines. *Petr. World* **19**, 75.

Recommended Practice for Concrete Oil Tank Construction.—*Oil News* **11**, 107, 134.

Security in Handling Inflammable Liquids.—*Chem. Age (London)* **5**, 372. *Chem. Abstr.* **15**, 4051.

The Flow of Fluids through Commercial Pipe Lines.—R. E. Wilson, W. H. McAdams & M. Seltzer. *J. Ind. Eng. Chem.* **14**, 105. *Oil Engineering and Finance* **1**, 250.

STATIC AND GASOLINE FIRES.—*Sci. Amer.* **125A**, 135.

PRESSURE IN GASOLINE TANK CARS.—D. B. Dow. U.S. Bureau of Mines. *Oil Engineering and Finance* **1**, 165.

FILLING STATION.—Oklahoma Oil Jobbers' Association. *Oil Engineering and Finance* **1**, 166.

OIL PIPE LINES.—C. P. Bowie. *Min. and Oil Bull.* **7**, 731. *U.S. Bur. Mines Repts. Investigations*, 2164.

CHEMICAL FIRE FIGHTING.—W. A. Raine. *Union Oil Company of California Bull.* **1**, Nov., 8.

RISKS IN HANDLING AND STORING COAL, OIL AND BY-PRODUCTS.—C. E. Paige. *Am. Gas. J.* **115**, 315. *Chem. Abstr.* **15**, 4046.

PATENTS.

METHOD OF FIREPROOF STORING MOBILE FUEL.—L. W. Bates. Brit. Pat. 149,958. *J. Soc. Chem. Ind.* **41**, 6A.

OIL-PROOFING CONCRETE TANKS.—C. Ellis. U.S. Pat. 1,385,941.

APPARATUS FOR STORING AND DELIVERING INFLAMMABLE LIQUIDS. P. A. P. V. Mauclere. Brit. Pat. 166,551. *Chem. Abstr.* **15**, 44A.

FIRE-EXTINGUISHING LIQUID.—B. I. Corson. U.S. Pat. 1,401,210. *J. Soc. Chem. Ind.* **41**, 127A.

SYSTEM AND APPARATUS FOR SAFETY STORAGE AND DISTILLATION OF INFLAMMABLE AND OTHER LIQUID IN TANKS AND PIPINGS, IN WHICH IT IS PROTECTED FROM CONTACT WITH AIR.—P. A. P. V. Mauclere. Brit. Pat. 153,587. *J. Soc. Chem. Ind.* **41**, 128A.

DOME COVER FOR OIL CARS.—W. K. Bonham. U.S. Pat. 1,398,832.

TANK CAR CONSTRUCTION. A. Campbell. U.S. Pat. 1,397,676.

VALVE MECHANISM FOR TANK CARS.—M. A. Garrett. U.S. Pat. 1,399,608.

OIL-TANK VALVE.—W. E. James. U.S. Pat. 1,398,025.

STORING LIQUID FUEL ON SHIPS.—L. W. Bates. U.S. Pat. 1,379,241. *Chem. Abstr.* **15**, 3388.

REFINERY TECHNIQUE.

DISTILLATION METHODS AND ACCOMPLISHMENTS IN SEPARATION.—F. Frank. *Z. angew. Chem.* **34**, 336. *Chem. Abstr.* **15**, 3350.

OIL REFINING IN RUSSIA.—*Petr. World* **18**, 269. *Chem. Abstr.* **15**, 3390.

DE-OILING PARAFFIN.—A. Szekely. *Seifensieder.-Zeit.* **48**, 408. *Chem. Abstr.* **15**, 3392.

A STUDY OF REFINING PETROLEUM AND ITS DERIVATIVES, WITH SPECIAL REFERENCE TO THE COMODORO RIVADAVIA OIL FIELDS OF ARGENTINA.—R. Reichart. *Anales Soc. Quim. Argentina* **8**, 415.

HEAT TRANSFER.—W. H. McAdams and T. H. Frost. *J. Ind. Eng. Chem.* **14**, 13.

Conditions Which have Led to the Change of Policy in Refining Practice.—J. E. Hackford. *Oil Engineering and Finance* **1**, 25.

Procedure and Products of Petroleum Refining.—C. K. Francis. *Chem. Age (New York)* **29**, 271. *Chem. Abstr.* **15**, 3902.

Methods for Reclaiming B. S.—C. V. Fornes. *Petr. Age* **8**, (10), 33. *Chem. Abstr.* **15**, 3903.

Electrical Processes for the Dehydration of Crude Petroleum Emulsions.—*Petr. World* **18**, 401. *Chem. Abstr.* **15**, 3903.

Removing Wax from Cylinder Stock.—E. Petty. *Oil and Gas J.* **20**, (19), 89. *Chem. Abstr.* **15**, 3905.

Corrosion of Condenser Tubes.—O. Lasche. *Z. Metallkunde* **12**, 160. *Chem. Abstr.* **15**, 3973.

The Separation of Adherent Oil or Bitumen from Rock.—E. Fyleman. *J. Soc. Chem. Ind.* **41**, 14T.

Technical Purification of Crude Naphthenic Acids.—H. Burstin and B. Spanier. *Petroleum* **17**, 1329. *J. Soc. Chem. Ind.* **41**, 46A.

Employment of Superheated Steam for Heating Melting Pans and Stills.—H. Voss. *Chem. Zeit.* **46**, 17. *J. Soc. Chem. Ind.* **41**, 87A.

The Advantages of the Tubular Still.—J. E Hackford. *Oil Engineering and Finance*, **1**, 195.

Loss Due to Weathering Gasoline.—D. B. Dow. *Oil Engineering and Finance* **1**, 252.

Protection from Fumes in the Oil Industry.—W. D. Edwards. *Min. and Oil Bull.* **7**, 743.

Wax Extraction from California Crude Oil.—*Min. and Oil Bull.* **7**, 719, 752.

Patents.

Reclaiming Sludge Acid in Petroleum Refining.—W. H. Simonson and O. Mantius. U.S. Pat. 1,384,978. *Chem. Abstr.* **15**, 3742. *J. Soc. Chem. Ind.* **41**, 5A.

Emulsifying Oil or Asphalt. D. J. McSwiney. U.S. Pat. 1,384,805. *Chem. Abstr.* **15**, 3742.

Purification of (Petroleum) Hydrocarbons.—O. E. Bransky, Assr. to Standard Oil Co. 1,396,399. *J. Soc. Chem. Ind.* **41**, 5A.

Material for Decolorising Oil and Method of Producing the Same. P. W. Prutzman, Assr. to General Petroleum Corp. U.S. Pat. 1,397,113. *J. Soc. Chem. Ind.* **41**, 5A.

Process for the Purification of Naphthenic Acids and their Salts (from Petroleum Refining).—G. Thieme. Ger. Pat. 341,654. *J. Soc. Chem. Ind.* **41**, 6A.

Purifying Hydrocarbon Oils. C. I. Robinson. U.S. Pat. 1,387,868. *Chem. Abstr.* **15**, 4048.

PURIFYING HYDROCARBON OILS.—E. B. Cobb. U.S. Pat. 1,387,835. *Chem. Abstr.* **15**, 4048.

DECOLORISING VISCOUS HYDROCARBON OILS.—E. B. Cobb. U.S. Pat. 1,388,517. *Chem. Abstr.* **15**, 4048.

VISCOUS PETROLEUM OIL MIXTURE.—E. B. Cobb. U.S. Pat. 1,388,832. *Chem. Abstr.* **15**, 4048.

BITUMINOUS EMULSION.—C. S. Reeve, Assr. to Barrett Co. U.S. Pat. 1,398,201. *J. Soc. Chem. Ind.* **41**, 48A.

CLEANING CONDENSERS, ETC.—F. G. Martin. Brit. Pat. 164,165. *Chem. Abstr.* **16**, 3.

PURIFYING LIQUIDS.—A. J. H. Haddan. Brit. Pat. 163,505. *Chem. Abstr.* **16**, 132.

TRANSPARENT EMULSIONS.—T. M. Rector. U.S. Pat. 1,389,161. *Chem. Abstr.* **16**, 145.

PURIFYING HYDROCARBONS.—J. M. Treneer & C. S. Benjamin. Brit. Pat. 164,325.

PURIFICATION OF OIL COMPOSED MAINLY OF HYDROCARBONS.—T. Ono. Japan Pat. 37,383. *Chem. Abstr.* **16**, 160.

(FULLERS') EARTH-TREATING PROCESS AND PRODUCT.—R. G. Tellier. U.S. Pat. 1,402,112. *J. Soc. Chem. Ind.* **41**, 132A.

TREATING SPENT FULLER'S EARTH.—C. I. Robinson. Assr. to Standard Oil Co. U.S. Pat. 1,403,198. *J. Soc. Chem. Ind.* **41**, 132A.

NATURAL GAS.

THE OIL-GAS (NATURAL GAS) INDUSTRY IN POLAND.—S. Bartoszevicz. *Petr. Times* **7**, 59.

CARBON BLACK PRODUCED FROM NATURAL GAS IN 1920.—*U.S. Geol. Surv.*, Oct. 13. *J. Soc. Chem. Ind.* **41**, 60R.

CARBON BLACK PRODUCED FROM NATURAL GAS IN 1920.—E. G. Sievers. Separate from Mineral Resources of the United States, 1920, Pt. II. *J. Ind. Eng. Chem.* **14**, 89.

NATURAL GAS IN ITALY.—*G. Chim. Ind. App.*, Oct. *J. Soc. Chem. Ind.* **41**, 10R.

MANUFACTURE OF NATURAL GASOLINE.—*Oil and Gas J.* **20**, (19), 74. *Chem. Abstr.* **15**, 3903.

THE ABSORPTION OF GASOLINE FROM CASINGHEAD GAS BY ACTIVATED CHARCOAL.—H. R. Auerswals. *Mech. Eng.* **43**, 601. *Chem. Abstr.* **15**, 3903.

GASOLINE FROM NATURAL GAS.—V. W. Killick. *Oil Engineering and Finance* **1**, 190.

HOW TO GET BETTER SERVICE WITH LESS NATURAL GAS IN DOMESTIC GAS APPLIANCES.—*U.S. Bur. Standards Circular*, 116.

Patents.

Recovering Vapours from Gaseous Mixtures.—G. A. Burrell, C. L. Voress & V. C. Canter. U.S. Pat. 1,382,890. *Chem. Abstr.* **15**, 3535.

Process for the Production of Soot-Carbon, Retort-Graphite and Other Carbon Products, from Natural Gas.—I. Szarvassy and F H. Bensel. Assr. to Rütgerswerke A.-G. U.S. Pat. 1,398,751. *J. Soc. Chem. Ind.* **41**, 6A.

Carbon Black.—W. D. Bancroft. U.S. Pat. 1,390,480. *Chem. Abstr.* **16**, 320.

Apparatus for Extracting Vapours from Gaseous Mixtures. G. A. Burrell, G. G. Oberfell & C. L. Voress. Assrs. to Gasoline Recovery Corp. U.S. Pat. 1,402,340. *J. Soc. Chem. Ind.* **41**, 127A.

Method of Producing Carbon Black.—R. W. Rumbarger. Assr. to Southern Carbon Co. U.S. Pat. 1,401,737 and 1,401,738. *J. Soc Chem. Ind.* **41**, 149A.

Process of Producing Finely-Divided Carbon.—R. W. Poindexter. Assr. to N. Goodwin. U.S. Pat. 1,402,957. *J. Soc. Chem. Ind.* **41**, 149A.

Petrol and Other Motor Fuels.

"Lightened" Gasolines.—F. Bordas. *Ann. fals.* **13**, 539. *Chem. Abstr.* **15**, 3390.

Motor Fuel from Vegetation.—T. A. Boyd. *J. Ind. Eng. Chem.* **13**, 836. *Chem. Abstr.* **15**, 3734.

Role of the Chemist in Relation to the Future Supply of Liquid Fuel. H. Hibbert. *J. Ind. Eng. Chem.* **13**, 841. *Chem. Abstr.* **15**, 3734.

Synthetic Alcohols and Liquid Fuels.—G. C. Calvert. *Chem. Age* (London) **5**, 153. *Chem. Abstr.* **15**, 3735.

Flame.—C. A. French. *J. Soc. Automotive Engineers* **9**, 182. *Chem. Abstr.* **15**, 3735.

The Advantages, Production and Cost of Natalite, Motor Fuel.—*Intern. Sugar J.* **24**, 147, 213, 266, 386. *Chem. Abstr.* **15**, 3736.

Tetrahydronaphthalene.—A new engine fuel. J. B. Rathbun. *Petr. Age* **8**, (9), 76. *Chem. Age* **15**, 3739.

Motor Spirit Characteristics and Their Relation to Engine Efficiency. J. Kewley. *Petr. Times* **7**, 79.

Relationship of Natural Gasoline to the Motor Fuel Problem W. M. Welch. *Petr. Times* **7**, 99.

Practical Effects of Too Low Volatility.—O. C. Berry. *Petr. Times* **7**, 101. *Oil Paint and Drug Reporter, Petr. Sec.* **100** (28), 13.

Limitation Imposed on Economy by Volatility Changes in Motor Fuel.—F. C. Mock. *Petr. Times* **7**, 101. *Oil Paint and Drug Reporter, Petr. Sec.* **100**, (28), 13.

Requirements of Motor Vehicle Fuel.—H. M. Crane. Amer. Petr. Inst. *Petr. Times* **7**, 103.

NATURAL GAS-GASOLINE BLENDS.—D. B. Dow. *U.S. Bur. Mines Repts. Investigations*, 2279. *Chem. Abstr.* **16**, 159.

U.S. NATURAL GAS GASOLINE.—U.S. Geol. Surv. *Petr. World* **19**, 56.

NATURAL-GAS GASOLINE IN THE UNITED STATES IN 1920.—*Oil Engineering and Finance* **1**, 29.

FUEL FOR MOTOR TRANSPORT. Second Memorandum by the Fuel Research Board, Dept. of Scientific and Industrial Research. H.M. Stationery Office. *J. Soc. Chem. Ind.* **41**, 13R.

METHOD OF FRACTIONATING LIQUID MIXTURES AND ITS APPLICATION TO THE PREPARATION OF A MOTOR SPIRIT.—C. Mariller. *Comptes rend.* **173**, 1087. *J. Soc. Chem. Ind.* **41**, 3A.

TESTING MOTOR FUEL BENZENE.—Ganswindt. *Export-Anzeiger.* **21**, (17), 1. *Chem. Abstr.* **15**, 3904.

POSSIBILITIES OF THE PLANT GROWTH OF THE MOIST TROPICS TO FURNISH MATERIALS FOR LIQUID FUEL.—H. N. Whitford. *J. Ind. Eng. Chem.* **14**, 151. *Oil Engineering and Finance* **1**, 252.

MOTOR FUEL.—*U.S. Commerce Rept., p.* 1030.

NATURAL-GAS GASOLINE IN 1919.—E. G. Sievers. *Separate from Mineral Resources of the U.S.* 1919. Pt. II.

ACETYLENE AS AUTO MOTOR FUEL.—*Scient. Amer.* **125**A, 125.

QUANTITATIVE SURVEY OF THE PETROLEUM INDUSTRY FROM THE STANDPOINT OF PRODUCTION OF MOTOR FUEL.—Van H. Manning. *Oil Paint and Drug Reporter, Petr. Section* **100**, (28), 9.

REQUIREMENTS OF MOTOR VEHICLE FUEL.—H. M. Crane. *Oil Paint and Drug Reporter, Petr. Section* **100**, (28), 10.

VOLATILITY OF MOTOR FUEL AS MARKETED IN THE UNITED STATES.—N. A. C. Smith. *Oil Paint and Drug Reporter, Petr. Section* **100**, (28), 10.

WHAT CONSTITUTES TRUE VOLATILITY.—R. E. Wilson. *Oil Paint and Drug Reporter, Petr. Section* **100**, (28), 10.

PRESENT VARIATION IN THE QUALITY OF MOTOR FUEL; ITS EXTENT AND CAUSES.—C. K. Francis. *Oil Paint and Drug Reporter, Petr. Section* **100**, (28), 10.

THE UTILISATION OF EXHAUST HEAT FROM INTERNAL-COMBUSTION ENGINES. —*Oil Engineering and Finance* **1**, 209.

FUEL EFFICIENCY IN HIGH-COMPRESSION MOTORS.—*J. Soc. Chem. Ind.* **41**, 79R.

ALCOHOL AS MOTOR FUEL.—*J. Soc. Chem. Ind.* **41**, 79R.

ALCOHOL AS A COMBUSTION FUEL.—E. C. Freeland and W. S. Harvey. *Sugar* **23**, 432. *Chem. Abstr.* **15**, 4046.

AUTOMOTIVE-ENGINEERING RESEARCH.—H. C. Dickinson. *Jour. Soc. Automotive Eng.* **9**, 437.

THE FALLACY OF THE GASOLINE GRAVITY TEST.—R. E. Haylett. *Union Oil Co. of California Bull.* **1**, Sept., 3, Oct., 6.

FUEL RESEARCH DEVELOPMENTS.—C. F. Kettering. *J. Soc. Automotive Eng.* **9**, 291, 343.

Patents.

Fuel Gas from Heavy Hydrocarbons.—H. Blumenberg, Jr. U.S. Pat. 1,379,077. *Chem. Abstr.* **15**, 3388.

Blended Motor-Fuel.—A. Hayes. U.S. Pat. 1,378,658. *Chem. Abstr.* **15**, 3388.

Motor Fuel.—J. P. Foster. U.S. Pat. 1,384,946. *Chem. Abstr.* **15**, 3738.

Motor Spirit.—A. G. Burnell & R. W. Dawe. Brit. Pat. 171,566. *J. Soc. Chem. Ind.* **41**, 5A.

Composite Motor Fuel.—J. P. Foster. U.S. Pat. 1,384,946. *J. Soc. Chem. Ind.* **41**, 5A.

Motor-Fuel for Aeroplanes.—W. T. Schneiber. Assr. to U.S. Industrial Alcohol Co. U.S. Pat. 1,398,947. *J. Soc. Chem. Ind.* **41**, 6A.

Motor Fuel.—E. W. Stevens. U.S. Pat. 1,388,531. *Chem. Abstr.* **15**, 4046.

Recovering Values from Exhaust Gases of Internal-Combustion Engines.—A. J. Paris, Jr. U.S. Pat. 1,388,480. *Chem. Abstr.* **15**, 4047.

Motor Fuel.—W. T. Schneiber. Assr. to U.S. Industrial Alcohol Co. U.S. Pat. 1,398,948. *J. Soc. Chem. Ind.* **41**, 48A.

Motor Fuel.—F. W. Rohrs. U.S. Pat. 1,399,227. *J. Soc. Chem. Ind.* **41**, 48A.

Motor Spirit.—A. T. Wilford. Brit. Pat. 167,831. *Chem. Abstr.* **16**, 335.

Liquid Fuel.—J. M. A. Chevalier, P. Bourcet & H. Rednault. Brit. Pat. 168,308. *Chem. Abstr.* **16**, 334.

Casinghead Gasoline.—G. H. Taber, Jr. U.S. Pat. 1,390,472. *Chem. Abstr.* **16**, 339.

Arrangement for Purifying and Rendering Odourless the Exhaust Gases of Internal Combustion Engines and the like.—P. Wachtel. Assr. to W. Schmidding. U.S. Pat. 1,402,814. *J. Soc. Chem. Ind.* **41**, 131A.

Carburetor.—J. E. Alpine. U.S. Pat. 1,397,711.

Carburetor.—C. P. Buhl. U.S. Pat. 1,397,500.

Carburetor.—H. Csanyi. U.S. Pat. 1,398,067.

Means for Atomising and Igniting Liquid Fuel.—A. Doble. U.S. Pat. 1,399,010.

Liquid-Fuel Vaporiser.—G. P. Eustis. U.S. Pat. 1,398,370.

Carburetor.—W. G. Hemenway. U.S. Pat. 1,398,459.

Carburetor.—P. Landis. U.S. Pat. 1,398,640.

Carburetor.—A. Loomis. U.S. Pat. 1,399,065.

Carburetor.—C. C. Little. U.S. Pat. 1,399,353.

Carburetor Control Means for Gas Engines.—U.S. Pat. 1,399,519.

Carbureting Air for Internal-Combustion Engines.—J. M. Schutz. U.S. Pat. 1,397,744.

Carburetor.—H. K. Tarkington. U.S. Pat. 1,398,707.

Kerosene.

Patent.

Lowering the Boiling and Flash Points of Kerosene.—W. M. Wheeler. U.S. Pat. 1,387,876. *Chem. Abstr.* **15**, 4048.

Lubricants and Lubrication.

Lubricants for Special Purposes.—*Elektrochem. Z.* **27**, ii., 67.

The Proper Lubrication of Ball Bearings.—H. Burrie. Société des Roulements à Billes S.K.F. *Industrie Chimique* **8**, 276. *Chem. Abstr.* **15**, 3350.

Viscosities at High Temperatures of California and Eastern Lubricating Oils.—T. F. Ott. *Nat. Petr. News* **13**, (31), 90. *Chem. Abstr.* **15**, 3351.

Lubricants for Electric Street Railways.—Summer and Winter Grades G. R. Rowland. *Gen. Elec. Rev.* **24**, 999.

Lubrication of Locomotives.—E. L. Ahrons. The Locomotive Publishing Co.

Lubrication of Coal-Mining Machinery.—*Lubrication* **7**, (11), 1.

Expansion of Lubricating Oil.—W. F. Osborne. *Power. Oil Engineering and Finance* **1**, 209.

Lubricating Oil Specifications: the Difficulties of Selection.—E. A. Evans. *Oil Engineering and Finance* **1**, 222.

Motor Lubricants.—H. Moore. *Oil Engineering and Finance* **1**, 221.

Summer and Winter Grades of Lubricants.—Their application to electric street railways. *Lubrication* **7**, (8), 1.

Patents.

Lubricants.—J. Harger. Brit. Pat. 167,789. *Chem. and Met. Engineering* **25**, 1021. *Chem. Abstr.* **16**, 305.

Lubricating Oil.—J. F. Maloney. U.S. Pat. 1,384,703. *Chem. Abstr.* **15**, 3700.

Manufacture of Screw-Cutting Oil.—H. C. Claflin. U.S. Pat. 1,401,760 *J. Soc. Chem. Ind.* **41**, 91A.

Lubricants.—H. Langer. Brit. Pat. 164,303. *Chem. Abstr.* **16**, 132.

Lubricants.—O. Reynard and E. Edser. Brit. Pat. 164,107. *Chem. Abstr.* **16**, 132.

Lubricants.—J. E. Southcombe and H. M. Wells. Brit. Pat. 165,897. *Chem. Abstr.* **16**, 305.

Lubricating Oils.—J. E. Southcombe and H. M. Wells. Brit. Pat. 168,076. *Chem. Abstr.* **16**, 305.

Lubricating Composition.—W. H. Wood. U.S. Pat. 1,398,759.

Fuel Oil.

Mazout.—F. Laur. *J. Petrole* **21**, (6), 2. *Chem. Abstr.* **15**, 3739.

Developments in Oil Fuel Burning, 1921.—F. T. Addyman. Oil Engineering and Finance **1**, 33.

Fuel Oil and the Coal Strike.—J. V. Stevens. *Oil Engineering and Finance* **1**, 38.

Use of Fuel Oil in Birmingham.—*U.S. Commerce Rept.*, p. 843.

Observations and Comments on Oil Fuel Burning.—F. T. Addyman. *Oil Engineering and Finance* **1**, 205.

Fuel Oil To-day.—J. V. Stevens. *Oil Engineering and Finance* **1**, 207.

Efficient Steam Generation by Means of Oil.—*Oil Engineering and Finance* **1**, 210.

Efficiency in Use of Oil as Fuel.—W. N. Best. *Am. Inst. Min. and Met.* Separate No. 1088, *Min. and Metallurgy*, Aug., 17. Separate No. 1038, *Min. and Metallurgy*, Jan. (1921), 61.

The Production and Combustion of Mexican Fuel Oil.—Part 8. Economy in oil-burning operation. J. M. Pettingell & J. R. Carlson. *Combustion* **5**, 254.

Patents.

Liquid Fuel.—L. W. Bates. U.S. Pat. 1,382,456. *Chem. Abstr.* **15**, 3551.

Liquid Fuel.—L. W. Bates. U.S. Pat. 1,382,457. *Chem. Abstr.* **15**, 3551.

Stable Liquid Fuel Mixture.—L. W. Bates. U.S. Pat. 1,390,228. *Chem. Abstr.* **16**, 157.

Increasing Flash Point and Density of Hydrocarbon Fuels.—L. W. Bates. U.S. Pat. 1,390,233.

Fuel.—V. D. Fay & United Oil and Coal Corporation, Ltd. Brit. Pat. 168,352. *Chem. Abstr.* **16**, 334.

Diesel Oil and Engines.

Vegetable Oils for Internal-Combustion Engines.—R. E. Mathot, *Engineer* **132**, 138. *Chem. Abstr.* **15**, 3735.

Diesel-Engine Flexibility.—W. S. Burn. N.E. Coast Institution of Engineers and Shipbuilders. *Petr. World* **19**, 69.

Some Recent Developments in Mechanical Injection Engines Using Heavy Oils.—O. Wans, Diesel Engine Users Association. *Petr. World* **19**, 73.

Survey of Oil Engine Progress and Development during 1921.—W. P. Sillence. *Oil Engineering and Finance* **1**, 43.

Fuel Oil in Diesel Engines.—*Oil Engineering and Finance* **1**, 48.

The Doom of the Condensing Steam Engine and Turbine.—D. Brownlie. *Oil Engineering and Finance* **1**, 49.

A Survey of Power Oils.—H. Moore. *Oil Engineering and Finance* **1**, 36.

Diesel Engines, Pt. II.—Two-Cycle, Solid Injection, etc. *Lubrication* **7**, (10), 1.

Oil Engines of Medium Power.—W. P. Sillence. *Oil Engineering and Finance* **1**, 213.

Small Oil Engines.—W. P. Sillence. *Oil Engineering and Finance* **1**, 215.

Oils for Power and Allied Purposes.—H. Moore. *Oil Engineering and Finance* **1**, 219.

History of Heavy-Oil Development on the Pacific.—D. L. Pratt. *Motorship* **6**, 640.

Plant and Machinery.

Orifice Meter for Gases or Liquids.—J. H. Satterwhite. *Gas Age-Record* **48**, 521. *Chem. Abstr.* **16**, 154.

Firefoam Protection of Extra-Hazardous Risks in Manufactories.—R. M. Patterson. *Chem. Met. Eng.* **25**, 887. *Chem. Abstr.* **16**, 304.

Patents.

Purifying Crude Petroleum.—J. W. Bostick & C. H. Homer. U.S. Pat. 1,380,863. *Chem. Abstr.* **15**, 3392.

Re-run Petroleum Still.—D. Pyzel. U.S. Pat. 1,383,024.

Apparatus for Dehydrating Petroleum Oils by Electric Treatment.—H. R. Quinby. U.S. Pat. 1,382,234.

Method of Distilling Liquids, such as Mineral Oils, Alcohol, and the like.—L. Granger, C. Mariller & Soc. Gén. d'Evaporation. Brit. Pat. 154,558. *J. Soc. Chem. Ind.* **41**, 4A.

Method of Distilling Petroleum.—E. T. Burch. U.S. Pat. 1,396,249. *J. Soc. Chem. Ind.* **41**, 5A.

Electrically-Heated Still.—C. G. Adsit. U.S. Pat. 1,386,484. *Chem. Abstr.* **15**, 3774.

Apparatus for Fractional Distillation of Liquids.—H. F. Perkins. U.S. Pat. 1,386,200. *Chem. Abstr.* **15**, 3774.

Distilling Mineral Oils.—E. A. Rudigier. U.S. Pat. 1,386,768. *Chem. Abstr.* **15**, 3905.

Fractional Distillation.—V. T. Gilchrist. U.S. Pat. 1,386,467. *Chem. Abstr.* **15**, 3905.

(Plates for) Distilling and Rectifying Columns.—E. Barbet et Fils et Cie. Brit. Pat. 151,988. *Chem. Abstr.* **15**, 43A.

Oil Distilling Apparatus.—T. J. Ryan. U.S. Pat. 1,397,984. *J. Soc. Chem. Ind.* **41**, 47A.

Oil Distilling Apparatus. D. A. Dean. U.S. Pat. 1,398,587. *J. Soc. Chem. Ind.* **41**, 48A.

METHOD OF TREATING ASPHALTIC (MINERAL) OILS.—P. Prutzman & G. L. Goodwin. Assr. to General Petroleum Corp. U.S. Pat. 1,399,792. *J. Soc. Chem. Ind.* **41**, 48A.

VAPOUR CONDENSING APPARATUS.—G. McD. Johns. Brit. Pat. 172,393. *J. Soc. Chem. Ind.* **41**, 88A.

VACUUM DISTILLATION PLANT (FOR OIL RECOVERY).—Dampfkessel u. Gasometer-Fabr. A.-G. vorm. A. Wilke u. Co. & P. Kulka. Ger. Pat. 341,836. *J. Soc. Chem. Ind.* **41**, 89A.

PROCESS FOR SEPARATING SOLID AND LIQUID HYDROCARBONS FROM EACH OTHER.—Deutsche Erdöl A.-G. Brit. Pat. 149,347. *J. Soc. Chem. Ind.* **41**, 91A.

IMPROVEMENT IN OR RELATING TO A PROCESS, AND TO APPARATUS FOR DEHYDRATING HYDROCARBON EMULSION AND-OR FOR DISTILLING HYDROCARBON OILS OR THEIR PRODUCTS OF DISTILLATION.—The Asiatic Petroleum Co. & W. Cameron. Brit. Pat. 173,644. *Oil Engineering and Finance* **1**, 189.

METHOD OF FRACTIONAL DISTILLATION.—F. Hansgirg. U.S. Pat. 1,398,856. *Chem. Abstr.* **15**, 43A.

APPARATUS FOR STRAINING OR FILTERING WATER, OIL OR OTHER LIQUIDS.—P. J. Darlington. U.S. Pat. 1,389,939. *Chem. Abstr.* **15**, 3.

DISTILLING OILS.—J. G. P. Evans. Brit. Pat. 163,173. *Chem. Abstr.* **16**, 160.

PETROLEUM OIL STILL.—J. Primrose. U.S. Pat. 1,389,978. *Chem. Abstr.* **16**, 160.

PETROLEUM STILL.—W. D. Rial. U.S. Pat. 1,390,386. *Chem. Abstr.* **16**, 339.

OIL-REFINING APPARATUS.—H. L. Allan. U.S. Pat. 1,390,742. *Chem. Abstr.* **16**, 339.

PARAFFIN WAX, ETC.—P. T. Sharples. Brit. Pat. 166,031. *Chem. Abstr.* **16**, 339.

PROCESS AND APPARATUS FOR DEHYDRATING HYDROCARBON EMULSIONS AND/OR DISTILLING HYDROCARBON OILS OR THEIR PRODUCTS OF DISTILLATION.—Asiatic Petroleum Co., Ltd. & W. Cameron. Brit. Pat. 173,644. *J. Soc. Chem. Ind.* **41**, 131A.

METHOD OF PURIFYING OILS.—C. M. Alexander. Assr. to Gulf Refining Co. U.S. Pat. 1,402,733.

TESTING, ANALYSIS AND APPARATUS.

VISCOSIMETERS.—F. W. Shulenberger. *Paint, Oil Chem. Rev.* **72**, (3), 10. *Chem. Abstr.* **15**, 3231.

CORROSION TEST FOR LUBRICATING OILS.—H. G. Smith. *Petr. Age* **8**, (8), 48. *Chem. Abstr.* **15**, 3350.

METHOD FOR DETERMINING THE DENSITY OF RESIDUUM.—C. Predescu. *Bull. sec. sci. acad. Roumaine* **6**, 148. *Chem. Abstr.* **15**, 3389.

MONTAN WAX AND A NEW METHOD FOR DETERMINING THE ACID NUMBER AND SAPONIFICATION NUMBER OF DARK-COLOURED OILS FATS AND WAXES.—P. Schoir, J. K. Pfaff & W. Berndt. *Z. angew. Chem.* **34**, 334. *Chem Abstr.* **15**, 3391.

GUIDES TO ANALYSIS. IX.—The interpretation of asphalt analyses.—H. J. Rossbacher. *Chem. Bull (Chicago)* **8**, 151. *Chem. Abstr.* **15**, 3392.

THE DETERMINATION OF WATER IN OILS FOR TRANSFORMERS.—E. Rengade & J. Clostre. *Compt. rend.* **173**, 311. *Chem. Abstr.* **15**, 3432.

IMPROVED MACMICHAEL VISCOSIMETER.—F. W. Shulenberger. *Paint, Oil and Chem. Rev.* **72**, (7), 10. *Chem. Abstr.* **15**, 3571.

DETERMINATION OF SALT IN PETROLEUM.—R. R. Matthews. *J. Ind. Eng. Chem.* **14**, 80.

REFRACTOMETRIC EXAMINATION OF PETROLEUM AND PETROLEUM PRODUCTS.—Utz. *Petroleum* **17**, 1293. *J. Soc. Chem. Ind.* **41**, 2A.

THE DRACORUBIN TEST OF HYDROGENATED COMPOUNDS.—W. Schrauth & O. von Keussler. *Auto-Technik* **10**, 3. *Chem. Zentr.* **92**, iv., 1191. *J. Soc. Chem. Ind.* **41**, 3A.

AMERICAN SOCIETY FOR TESTING MATERIALS STANDARDS.—American Society for Testing Materials. *Chem. Abstr.* **15**, 3884.

DETERMINATION OF THE PERCENTAGE OF DILUTION OF LUBRICANTS FOR INTERNAL-COMBUSTION ENGINES.—C. M. Larson. *Sci. Lubrication* 1, June, 16. *Chem. Abstr.* **15**, 3885.

DETERMINATION OF ABSOLUTE VISCOSITY BY THE GUMBEL VISCOSIMETER.—L. Schiller. *Z. tech. Physik* **2**, 50. *Science Abstracts* **24A**, 316. *Chem. Abstr.* **15**, 3779.

HEAT TEST OF OIL.—C. V. Stratford. *J. Soc. Auto. Eng.* **9**, 280. *Chem. Abstr.* **15**, 3903.

THE ESTIMATION OF SULPHUR IN OILS.—H. Hauser. *Anales Soc. Espan. fis. Quim.* **19**, 175. *Chem. Abstr.* **15**, 3957.

DISTILLATION PRINCIPLES AND PROCESSES.—S. Young & Collaborators. Macmillan and Co. London.

NEW VISCOSTALAGMOMETER FOR THE ESTIMATION OF SURFACE TENSION AND VISCOSITY OF LIQUIDS OF VERY DIFFERENT FLUIDITY.—I. Traube. *Biochem. Zeits.* **120**, 106.

SEPARATION OF MISCIBLE LIQUIDS BY DISTILLATION.—A. F. Dufton. *J. Chem. Soc.* **119**, 1988. *J. Soc. Chem. Ind.* **41**, 121A.

ACIDITY IN OILS.—*Lubrication* **7**, (10), 11.

DETERMINING THE DEW POINT OF GASOLINE.—R. W. Wilson. *J. Soc. Autom. Eng.* **9**, 265. *Chem. Abstr.* **16**, 158.

MEASUREMENT OF SURFACE TENSION OF OILS.—R. v. Dallurtz-Wegner. *Z. angew. Chem.* **34**, 433. *Chem. Abstr.* **16**, 168.

A SIMPLE, EFFICIENT FRACTIONATING COLUMN.—G. Dupont. *Bull. officiel direction recherches sci. ind. inventions* **22**, 485. *Chem. Abstr.* **16**, 178.

A RECEIVER FOR FRACTIONATION IN A CURRENT OF GAS OR UNDER REDUCED PRESSURE.—F. S. Wheeler. *J. Soc. Chem. Ind.* **41**, 59T.

APPARATUS FOR DETERMINING RESISTANCE TO COLD OF MINERAL OILS.—K. Glaser. *Petroleum* **18**, 81. *J. Soc. Chem. Ind.* **41**, 129A.

METHOD OF DETERMINING OIL AND WATER IN PARAFFIN WAX.—C. K. Francis & H. T. Bennett. *Nat. Petroleum News* **13**, 31. *Oil Engineering and Finance* **1**, 114.

TENTATIVE METHOD OF TESTING FOR LUBS PRECIPITATION NUMBER. *Nat. Petroleum News* **13**, 41. Nov. 30, 41.

TENTATIVE TEST FOR FLASH POINT WITH PENSKY-MARTENS CLOSED CUP. *Nat. Petroleum News* **13**, Dec. 7, 57.

PATENTS.

METHOD AND APPARATUS FOR DETERMINING VISCOSITY.—A. G. M. Mitchell. U.S. Pat. 1,398,878.

METHODS AND APPARATUS FOR DETERMINING THE VISCOSITY OF HIGHLY-VISCOUS MATERIALS.—R. L. Frink. Brit. Pat. 171,774. *J. Soc. Chem. Ind.* **41**, 83A.

CRACKING AND HYDROGENATION.

MANUFACTURE OF MOTOR SPIRIT BY CRACKING PROCESSES. *Chem. Age* **4**, 678. *Chem. Abstr.* **15**, 3389.

BENZINE FROM HEAVY HYDROCARBONS.—R. von Walther. *Z. angew. Chem.* **34**, 329. *Chem. Abstr.* **15**, 3390.

NEW METHODS FOR THE UTILISATION OF MINERAL OILS AND COAL.—F. Bergius. *Z. angew. Chem.* **34**, 341. *Chem. Abstr.* **15**, 3390.

COMBUSTIBLE MATERIAL FROM PARAFFIN BY CATALYSIS.—Mailhe. *Petr.* **17**, 265. *Tech. Rev.* **8**, (2), 38. *Chem. Abstr.* **15**, 3741.

DEGREE OF UNSATURATION OF MINERAL OILS IN THE BERGIUS (HYDROGENATION) PROCESS.—H. I. Watermann & J. N. J. Perquin. *Rec. Trav. Chim.* **40**, 677. *J. Soc. Chem. Ind.* **41**, 3A.

PERKIN MEDAL AWARD—ADDRESS OF ACCEPTANCE.—W. M. Burton. *J. Ind. Eng. Chem.* **14**, 162. *J. Soc. Chem. Ind.* **41**, 50R. *Oil Engineering and Finance* **1**, 161.

THE PRESSURE STILLS.—J. L. Finley. *The Oil Weekly* **24**, 7.

ARTIFICIAL RESIN AND ARTIFICIAL BENZINE BY THE MELAMID PROCESS.—O. Beyer. *Schweiz. Chem. Zeit.* **1921**, 459. *Chem. Abstr.* **16**, 329.

PATENTS.

J. W. COAST.—1,379,333. *Chem. Abstr.* **15**, 3393.

D. W. HOGE.—U.S. Pat. 1,382,727. *Chem. Abstr.* **15**, 3553.

C. M. ALEXANDER and G. H. TABER, JR.—U.S. Pat. 1,381,098. *Chem. Abstr.* **15**, 3553.

STANDARD OIL CO. Assees. of H. P. Chamberlain. Brit. Pat. **164,358**. *J. Soc. Chem. Ind.* **41**, 5A.

E. F. ENGELKE.—Brit. Pat. 166,989. *J. Soc. Chem. Ind.* **41**, 5A.

J. T. Fenton.—U.S. Pat. 1,396,174. *J. Soc. Chem. Ind.* **41**, 5A.

C. Ellis.—U.S. Pat. 1,396,999. *J. Soc. Chem. Ind.* **41**, 5A.

F. Puening (Reissue 15,239).—U.S. Pat. 1,358,174. *J. Soc. Chem. Ind.* **41**, 6A.

D. E. Day.—U.S. Pat. 1,386,768. *Chem. Abstr.* **15**, 3905.

J. W. Coast, Jr.—U.S. Pat. 1,388,629.

E. M. Clark.—U.S. Pat. 1,388,514. *Chem. Abstr.* **15**, 4048.

C. Ekstrand.—U.S. Pat. 1,388,415. *Chem. Abstr.* **15**, 4048.

H. P. Chamberlain. Assr. to Standard Oil Co. U.S. Pat. 1,400,419. *J. Soc. Chem. Ind.* **41**, 48A.

J. Nelson.—Brit. Pat. 172,035. *J. Soc. Chem. Ind.* **41**, 65A.

M. Brutzkus.—Brit. Pat. 149,915. *J. Soc. Chem. Ind.* **41**, 87A.

R. D. George.—Brit. Pat. 151,925. *J. Soc. Chem. Ind.* **41**, 91A.

J. W. Coast, Jr., Assr. to The Process Co.—U.S. Pat. 1,400,800. *J. Soc. Chem. Ind.* **41**, 91A.

R. H. Brownlee and C. F. de Ganahl.—Brit. Pat. 172,242. *Oil Engineering and Finance* **1**, 220. *J. Soc. Chem. Ind.* **41**, 131A.

F. A. Wellman.—U.S. Pat. 1,390,002. *Chem. Abstr.* **16**, 159.

C. R. Burke.—U.S. Pat. 1,389,934. *Chem. Abstr.* **16**, 159.

V. L. Emerson.—Brit. Pat. 162,277. *Chem. Abstr.* **16**, 160.

C. Dalley.—Brit. Pat. 163,347. *Chem. Abstr.* **16**, 160.

Standard Oil Co.—Brit. Pat. 164,358. *Chem. Abstr.* **16**, 160.

J. Nelson.—U.S. Pat. 1,391,568. *Chem. Abstr.* **16**, 339.

N. V. S. Knibbs.—Brit. Pat. 165,863. *Chem. Abstr.* **16**, 339.

W. O. Snelling.—U.S. Pat. 1,402,455. *J. Soc. Chem. Ind.* **41**, 132A.

W. T. Bryant.—Assr. to E. R. Ratcliffe. U.S. Pat. 1,403,145. *J. Soc. Chem. Ind.* **41**, 132A.

A. S. Ramage.—Assr. to F. F. Beall. U.S. Pat. 1,403,194. *J. Soc. Chem. Ind.* **41**, 132A.

E. V. Stone.—U.S. Pat. 1,403,457 and 1,403,458.

U.S. Pat. 1,401,113. *J. Soc. Chem. Ind.* **41**, 132A.

Insulating Oils.

Transformer Oil Sludge.—C. J. Rodman. *Trans Am. Elektrochem. Soc.* **40**. *Chem. Abstr.* **15**, 3593.

Dehydration of Transil Oils by Centrifugal Force.—C. H. Hapgood. *Elec. World* **78**, 473. *Chem. Abstr.* **15**, 3698.

Dielectric (Breakdown) Value of Insulating Oils.—R. M. Friese. *Wiss. Veroffentl. Siemens Konzern* **1**, 41. *Chem. Zentr.* **92**, iv., 1349. *J. Soc. Chem. Ind.* **41**, 147A.

Shale and Shale Oils.

Present Status of American Oil Shale Development.—M. J. Gavin, H. H. Hill & W. E. Perdew. *Chem. Age (N.Y.)* **29**, 305. *Chem. Abstr.* **15**, 3391.

Shale Oil.—A. Spiegel. *Z. angew. Chem.* **34**, 321. *Chem. Abstr.* **15**, 3391.

Nature of Shale Oil Obtained from Oil-Shale Assay Retort Used by the Bureau of Mines.—M. J. Gavin & L. C. Karrick. *U.S. Bur. Mines Repts. Investigations* 2254. *Chem. Abstr.* **15**, 3391.

Producing Oil from Shale.—N. H. Freeman. *Petr. Times* **6**, 151. *Chem. Abstr.* **15**, 3391.

Flotation Oils from Shale.—J. M. McClane. *Petr. Times* **6**, 11. *Chem. Abstr.* **15**, 3392.

Contribution to the Knowledge of the Composition of Swedish Shale Oil.—G. Hellsing. *Arkiv. Kemi. Mineral. Geol. Stockholm* **7**, (29), 23.

Development of the Oil Shales of Esthonia.—J. Kukk. *Petr. Times* **7**, 27.

The Freeman Multiple Retort. *Petr. Times* **7**, 43.

Oil Shale Industry in Russia.—L. Litinsky. *Petroleum* **17**, 368. *Chem. Abstr.* **15**, 3740.

The Investigation of a Bituminous Shale.—M. Dolch. *Petroleum* **15**, 881. *Chem. Abstr.* **15**, 3740.

Studies in Colorado Shale Oils.—A. J. Franks. *Chem. and Met. Eng.* **25**, 49. *Chem. Abstr.* **15**, 3741.

Laboratory Study of Colorado Shales.—R. D. George. *Railroad Red Book* **38**, 734. *Chem. Abstr.* **15**, 3741.

Shaloilogy and Oil Shale Nomenclature.—J. B. Jenson. *Petr. Times.* **7**, 95.

The Oil Shale Industry.—G. Howell. *Oil Engineering and Finance* **1**, 18.
Colorado Shales.—*Oil Engineering and Finance* **1**, 112.

The Thermal Decomposition of Shales.—R. H. McKee & E. E. Lyder. *Petr. Times* **7**, 133, 237, 277.

Origin and Composition of Certain Oil Shales.—R. Thiesen. *Econ. Geol.* **16**, 289. *Chem. Abstr.* **15**, 3807.

Notes on the Oil-Shale Industry with Particular Reference to the Rocky Mountain District.—M. J. Gavin, H. H. Hill & W. E. Perdew. *U.S. Bur. Mines Rept. Investigations* 2256. *Chem. Abstr.* **15**, 3904.

Present Availability of Oil Shale.—F. P. Webb. *Am. Gas. J.* **115**, 271. *Chem. Abstr.* **15**, 3904.

The Colorado-Utah Petro-Shales.—J. B. Benson. *Petr. Times* **6**, 4691. *Chem. Abstr.* **15**, 3904; **16**, 159.

The Thermal Decomposition of Shales. I. Heat Effects. R. H. McKee & E. E. Lyder. *J. Ind. Eng. Chem.* **13**, 613. *Chem. Abstr.* **15**, 3904.

THE THERMAL DECOMPOSITION OF SHALES. II. DETERMINATION OF THE HEAT OF REACTION INVOLVED IN THEIR DECOMPOSITION.—*J. Ind. Eng. Chem.* **13**, 678. *Chem. Abstr.* **15**, 3905.

ESTHONIAN OIL SHALE INDUSTRY.—*Oil News* **11**, 110.

THE SHALE OIL INDUSTRY (NEW SOUTH WALES).—*Times Tr. Suppl. Dec.* 31. *J. Soc. Chem. Ind.* **41**, 31R.

APPARATUS FOR STUDYING THERMAL DECOMPOSITION OF OIL SHALES.—R. H. McKee & E. E. Lyder. *Chem. Met. Eng.* **25**, 1100. *J. Soc. Chem. Ind.* **41** 45A.

SOLUBILITY OF OIL SHALES IN SOLVENTS FOR PETROLEUM.—M. J. Gavin. *U.S. Bur. Mines Report. Oil Engineering and Finance* **1**, 133. *Petr. Times* **7**, 199.

THE MECHANICAL CONSTRUCTION OF THE "DAY" RETORT.—*Petr. Times* **7**, 186.

GREAT BRITAIN'S OIL INDUSTRY.—J. A. Greene. *Oil Engineering and Finance* **1**, 193.

OIL SHALE—A RESUME FOR 1921.—V. C. Alderson. *Petr. Times* **7**, 259.

OIL SHALES OF ESTHONIA.—*U.S. Consular Rept.* 1028. *Petr. World* **19**, 104.

GASOLINE FROM OIL SHALES.—*Oil Engineering and Finance* **1**, 256.

SHALE OIL DATA.—E. M. Bailey. *Oil and Gas J.* **20**, (20), 82. *Chem. Abstr.* **16**, 159.

WURTTENBERG OIL SHALES.—F. C. Gaisser. *Chem. Zeit.* **45**, 837. *Chem. Abstr.* **16**, 337.

STUDIES IN COLORADO SHALE OILS.—A. J. Franks. *Chem. and Met. Eng.* **25**, 731, 778. *Colorado School of Mines Quart.* **16**, (4), 39.

RECENT WORLD-WIDE PROGRESS IN OIL SHALE DEVELOPMENT.—V. C Alderson. *Colorado School of Mines Circular of Information*, 1921 *Combustion* **5**, 251, 260, 265.

A SYMPOSIUM OF STUDIES AND RESEARCHES IN THE OIL SHALE INDUSTRY.—A. J. Franks. *Colorado School of Mines Quart.* **16**, (4).

OIL SHALES OF COLORADO.—R. D. George. *Colorado Geol. Surv. Bull.* 25.

COMMERCIAL PRODUCTION OF SHALE OIL.—J. A. Bishop. *Salt Lake Min. Rev.* **23**, Nov. 30, 14,

PATENTS.

RETORT FOR DISTILLING OIL-SHALE OR SIMILAR MATERIALS.—S. Schieffelin. U.S. Pat. 1,381,936. *Chem. Abstr.* **15**, 3553.

APPARATUS FOR DISTILLATION OF OIL SHALE.—E. E. Hedges. U.S. Pat. 1,383,205. *Chem. Abstr.* **15**, 3553.

FURNACE FOR DISTILLATION OF OIL-SHALE, OR SIMILAR MATERIALS.—J. N. Wingett. U.S. Pat. 1,384,878. *Chem. Abstr.* **15**, 3742.

PROCESS AND APPARATUS FOR TREATING OIL-BEARING SOLIDS.—J. T. Fenton. —U.S. Pat. 1,396,173. *J. Soc. Chem. Ind.* **41**, 5A.

PROCESS FOR DISTILLING BITUMINOUS SAND, COAL, OIL SHALE, AND OTHER MATERIALS WHICH YIELD HYDROCARBONS.—A. E. O'Dell. From the Canadian American Finance and Trading Co., Ltd. Brit. Pat. 171,213. *J. Soc. Chem. Ind.* **41**, 6A.

SUPERPOSED HORIZONTAL RETORTS FOR DISTILLATION OF OIL FROM SHALE OR SAND.—J. B. Jenson. U.S. Pat. 1,388,718. *Chem. Abstr.* **15**, 4048.

METHOD OF TREATING OIL SHALES.—S. H. Dolbear. Brit. Pat. 171,918. *J. Soc. Chem. Ind.* **41**, 47A. *Petr. Times* **7**, 262.

PROCESS OF DISTILLATION OF MATERIAL (OIL SHALE, ETC.) CARRYING A PERCENTAGE OF VOLATILE MATTER. RETORTS.—G. McD. Johns. Brit. Pat. 172,392.

PROCESS OF DISTILLATION OF MATERIAL (OIL SHALE, ETC.) CARRYING A PERCENTAGE OF VOLATILE MATTER. RETORTS.—G. McD. Johns, J. H. Curran, F. W. Lowe & J. B. Trescott. Brit. Pat. 172,401.

APPARATUS FOR DISTILLING COAL OR SHALE.—H. E. Lutz. U.S. Pat. 1,389,203. *Chem. Abstr.* **16**, 157.

DESTRUCTIVE DISTILLATION.—W. E. Davies. Brit. Pat. 165,825. *Chem. Abstr.* **16**, 335.

APPARATUS FOR DEVOLATISING COAL OR SHALE.—C. M. Garland. U.S. Pat. 1,291,825. *Chem. Abstr.* **16**, 335.

LIGNITES AND COALS AND THEIR PRODUCTS.

IMPORTANCE OF MONTAN WAX FOR LUBRICANT FACTORIES.—H. Pomeranz. *Kunststoffe* **10**, 85. *Chem. Abstr.* **15**, 3350.

INVESTIGATION OF THE BROWN COAL OF BOSNIA AS TO ITS SUITABILITY FOR PREPARATION OF TAR.—Gvosdz. *Feuerungstechnik* **9**, 165. *Chem. Abstr.* **15**, 3382.

CARBONISATION OF COAL AT LOW TEMPERATURE.—J. Roberts. *Iron and Coal Trades Rev.* **103**, 193. *Gas World* **75**, 129. *Chem. Abstr.* **15**, 3383.

PRESENT POSITION OF SMOKELESS FUELS.—F. S. Sinnatt. *Gas J.* **155**, 385. *Iron and Coal Trades Rev.* **103**, 233. *J. Roy. Sanitary Inst.* **42**, (1). *Chem. News* **123**, 109. *Chem. Abstr.* **15**, 3383.

LOW TEMPERATURE TAR PRODUCTION AND THE GAS INDUSTRY.—Bunte. *Brennstoff Chem.* **2**, 202. *Chem. Abstr.* **15**, 3386.

SOURCES OF TAR IN SAXON-THURINGIAN LIGNITES. E. Erdmann. *Z. angew. Chem.* **34**, 309. *Chem. Abstr.* **15**, 3386.

COMPOSITION OF HIGH AND LOW TEMPERATURE TARS.—J. Marcusson & M. Picard. *Z. angew. Chem.* **34**, 201. *Chem. Abstr.* **15**, 3386.

REMARKS ON THE ARTICLE BY MARCUSSON & PICARD ON "COMPOSITION OF HIGH-AND-LOW-TEMPERATURE TARS."—A. Grün. *Z. angew. Chem.* **34**, 355. *Chem. Abstr.* **15**, 3387.

THE INFLUENCE OF DRYING LIGNITE ON THE YIELD OF LOW-TEMPERATURE TAR IN ITS SUBSEQUENT GASIFICATION.—F. Seidenschur. *Brennstoff Chem.* **2**, 241. *Chem. Abstr.* **15**, 3550.

COMPOSITION OF HIGH-AND-LOW-TEMPERATURE TARS.—H. Tropsch. *Brennstoff Chem.* **2**, 251. *Chem. Abstr.* **15**, 3550.

THE POSSIBLE APPLICATIONS OF LIGNITE BROWN COAL.—M. Dolch. *Montan. Rundschau* **13**, 170, 185, 206, 228, 249, 267. *Chem. Abstr.* **15**, 3733.

CONDITIONS UNDER WHICH BULK OIL CONCENTRATION OF FINE COAL GIVES BEST RESULTS.—G. St. J. Perrott & S. P. Kinney. *Coal Age* **20**, 172. *Chem. Abstr.* **15** 3734.

EVAPORATION TESTS IN BOILERS FIRED BY BROWN COAL.—*Arch. Warmewirtschaft* **2** 78. *Chem. Abstr.* **15**, 3734.

COAL DISTILLATION "TREES."—*Chem. Zeit.* **45**, 773. *Chem. Abstr.* **15**, 3734.

VARIETIES OF TAR.—M. Popel. *Chem. Zeit.* **45**, 580. *Chem. Abstr.* **15**, 3737.

LOW-TEMPERATURE TAR FROM A BOHEMIAN LIGNITE.—M. Dolch. *Petroleum* **17**, 77. *Chem. Abstr.* **15**, 3737.

THE PROPER UTILISATION OF COAL AND OTHER CARBONACEOUS MATERIAL.—*Oil Engineering and Finance* **1**, 21.

PREPARATION OF LIGHT MOTOR FUEL FROM TARS.—F. Fischer. *Brennstoff Chem. Oil Engineering and Finance* **1**, 120.

THE EFFICIENCY OF LOW-TEMPERATURE COKE IN DOMESTIC APPLIANCES.—M. W. Fishenden. *Fuel Research Board, Department of Scientific and Industrial Research, Tech. Paper No.* 3. H.M. Stationery Office. *J. Soc. Chem. Ind.* **41**, 13R.

LIGNITE PRODUCER TAR.—S. Ruhemann. *Ber.* **54**, 2565. *J. Soc. Chem. Ind.* **41**, 7A.

HIGH VACUUM DISTILLATION PLANT FOR LIGNITE TAR.—R. Neumann. *Petroleum* **17**, 1257. *J. Soc. Chem. Ind.* **41**, 7A.

PREPARATION OF VISCOUS LUBRICATING OILS FROM COAL TAR.—F. Schrieber. *Z. angew. Chem.* **34**, 425. *Chem. Abstr.* **15**, 3886.

THE CONVERSION OF COAL TO OIL BY MEANS OF HYDROGENATION. II. HYDROGENATION OF COAL BY MEANS OF CARBON MONOXIDE. F. Fischer & H. Schrader. *Brennstoff Chem.* **2**, 257. *Chem. Abstr.* **15**, 3900.

THE DEVELOPMENT OF FOREIGN LOW-TEMPERATURE COKING ON A LARGE SCALE.—A. Thau. *Brennstoff Chem.* **2**, 225, 244, 264. *Chem. Abstr.* **15**, 3901.

LOW-TEMPERATURE DISTILLATION OF AMALGAMS OF BITUMINOUS NON-COKING COAL AND ASPHALTIC OILS.—J. D. Davis. *Oil News* **11**, 108.

CARBONISATION OF WESTERN LIGNITE.—R. de L. French. *J. Soc. Chem. Ind.* **41**, 16T.

PRODUCTION OF MOTOR SPIRIT FROM LOW-TEMPERATURE TARS, FROM COAL AND LIGNITE, AND THE CONVERSION OF THE PHENOLS OR CREOSOTE INTO BENZOL.—F. Fischer. *Brennstoff Chem.* **2**, 327, 347. *J. Soc. Chem. Ind.* **41**, 46A.

DISTILLATION OF MIXTURES OF OIL AND COAL.—*Oil Engineering and Finance* **1**, 142.

LIGNITE CARBONISATION—CARBONISED RESIDUE BRIQUETS.—W. W. O'Dell. *U.S. Bur. Mines Repts. Investigations* 2298.

PRESENT STATUS OF COAL CARBONISATION AT LOW TEMPERATURES.—J. D. Davis. *U.S. Bur. Mines Repts. Investigations* 2292. *Chem. Abstr.* **16**, 331.

LIGNITE IN THE WESTERN PART OF THE FORT BERTHOLD INDIAN RESERVATION SOUTH OF MISSOURI RIVER, NORTH DAKOTA.—C. M. Bauer & F. A. Herald. Separate from contributions to *Econ. Geol.*, 1921, *Pt. II. U.S. Geol. Survey.*

LOW-TEMPERATURE DISTILLATION OF AMALGAMS OF BITUMINOUS NON-COKING COAL AND ASPHALTIC OILS.—J. D. Davis & C. E. Coleman. *Oil News* **11**, 143. *Chem. Met. Eng.* **26**, 173.

THE SUPPLY OF OIL FROM HOME SOURCES.—New Methods of Low-Temperature Carbonisation of Coal. *Oil Engineering and Finance* **1**, 157.

OIL AND COAL AS PLASTIC FUELS.—W. E. Trent. *Chem. and Met. Eng.* **26**, 22.

LOW-TEMPERATURE CARBONISATION IN ENGLAND.—D. Brownlie. *Chem. Met. Eng.* **26**, 23.

ECONOMICAL PRODUCTION OF LOW-TEMPERATURE TAR.—M. Dolch. *Z. angew. Chem.* **34**, 643. *Oil Engineering and Finance* **1**, 220. *J. Soc. Chem. Ind.* **41**, 133A.

CARBONISATION OF LIGNITE IN VERTICAL CHAMBER OVENS.—Müller. *Gas-und Wasserfach.* **64**, 585. *Chem. Abstr.* **16**, 155.

MANUFACTURE OF SMOKELESS FUEL.—*Engineering* **112**, 596. *Chem. Abstr.* **16**, 328.

SENSIBLE-HEAT LOW-TEMPERATURE DISTILLATION IN ROTARY RETORTS.—*Gas J.* **156**, 368. *Chem. Abstr.* **16**, 331.

CHEMICAL REVIEW OF CARBONISATION IN REVOLVING RETORTS AND RECOVERY OF LOW-TEMPERATURE TAR.—J. Becker. *Gas-und Wasserfach* **64**, 553, 374. *Chem. Abstr.* **16**, 332.

LOW-TEMPERATURE CARBONISATION AND ITS RELATION TO THE IRON AND STEEL INDUSTRY **9**, 645. *Chem. Abstr.* **16**, 332.

THE CHEMICAL USE OF LOW-TEMPERATURE TAR.—*Warme-Kalte Tech.* **23**, 157. *Chem. Abstr.* **16**, 333.

THE EXPOSITION OF LIGNITE TARS.—H. Strache & M. Dolch. *Montan Rundschau* **11**, 409, 450, 483, 550, 584, 611. *Chem. Abstr.* **16**, 333.

ASPHALTIC SUBSTANCES IN LIGNITE PRODUCER-GAS TAR.—J. Mzourek. *Petroleum* **18**, 77. *J. Soc. Chem. Ind.* **41**, 133A.

PRODUCTION OF LUBRICATING OIL FROM LIGNITE TAR-OIL.—M. Jacobsohn. *Brennstoff Chem.* **3**, 10. *J. Soc. Chem. Ind.* **41**, 134A.

DESTRUCTIVE DISTILLATION OF MIXTURES OF OIL AND COAL.—J. D. Davis, P. B. Place & G. S. Scott. *U.S. Bur. Mines Repts. Investigations* 2301, *Chem. Met. Eng.* **25**, 1131. *J. Soc. Chem. Ind.* **41**, 92A.

PATENTS.

FUEL BRIQUETS FROM LIGNITE.—S. M. Darling. U.S. Pat. 1,382,629. *Chem. Abstr.* **15**, 3551.

VERTICAL RETORT FOR DESTRUCTIVE DISTILLATION.—L. F. Schrader, W. E. Roberts & V. Bredlik. U.S. Pat. 1,382,746. *Chem. Abstr.* **15**, 3551.

CARBONISING COAL OR SIMILAR MATERIALS.—J. F. Wells. U.S. Pat. 1,383,888. *Chem. Abstr.* **15**, 3738.

PROCESS FOR PRODUCING AMMONIUM CHLORIDE (FROM COAL, ETC.).—O. L. Christensen & K. I. M. Gisiko. Gisiko, Assr. to B. A. Hedman. U.S. Pat 1,397,264. *J. Soc. Chem. Ind.* **41**, 4A.

PROCESS FOR THE PRODUCTION OF LUBRICATING AND MOTOR OILS.—R. Tern. Ger. Pat. 341,295. *J. Soc. Chem. Ind.* **41**, 5A.

PRODUCTION OF LUBRICATING OILS.—Chem. Fabr. Lindenhof C. Weyl und Co. A.-G. Ger. Pat. 341,686. *J. Soc. Chem. Ind.* **41**, 5A.

DISTILLATION OF LIGNITE PRODUCER-GAS TAR.—F. W. Klever. Ger. Pat. 340,314. *J Soc. Chem. Ind.* **41**, 7A.

FUEL FROM LIGNITIC COAL.—C. H. Urquhart. U.S. Pat. 1,386,473. *Chem. Abstr.* **15**, 3902.

MEANS OF COMBINATION OF SOLID AND LIQUID FUELS.—G. P. Lewis. Brit. Pat. 172,065. *J. Soc. Chem. Ind.* **41**, 46A.

PRODUCTION OF HIGH-GRADE, NON-HYGROSCOPIC FUEL FROM LOW-GRADE FUEL SUCH AS LIGNITE, PEAT, OR THE LIKE.—I. Schenk. Ger. Pat. 339,743. *J. Soc. Chem. Ind.* **41**, 46A.

PRODUCTION OF MONTAN WAX FROM LIGNITE.—A. Riebeckschc Montanwerke A.-G.. Ger. Pat. 341,763. *J. Soc. Chem. Ind.* **41**, 48A.

PRODUCTION OF VISCOUS LUBRICATING OIL AND PARAFFIN FROM THE HIGH-BOILING FRACTIONS OF PRODUCER AND LOW-TEMPERATURE TAR. Allgem. Ges. für Chem. Ind. m.b.H. Ger. Pat. 341,872. *J. Soc Chem Ind.* **41**, 48A.

LOW-TEMPERATURE DISTILLATION OF FUEL.—Marz & McLellan, W. T. Bottomley & E. G. Weeks. Brit. Pat. 171,909. *J. Soc. Chem. Ind.* **41**, 48A.

APPARATUS FOR DISTILLING FUEL AND BITUMINOUS ROCKS.—C. Magri. U.S. Pat. 1,399,367. *J. Soc. Chem. Ind.* **41**, 48A.

DISTILLATION OF LIGNITE PRODUCER TAR.—F. W. Klever. Ger. Pat. 340,784. *J. Soc. Chem. Ind.* **41**, 50A.

PRODUCTION OF PALE, NON-DARKENING PHENOLS FROM LIGNITE TAR OR ITS DISTILLATES.—M. Pfautsch. Ger. Pat. 341,231. *J. Soc. Chem. Ind.* **41**, 93A.

DRYING PEAT, LIGNITE, ETC.—K. W. Jacobs. Brit. Pat. 163,719. *Chem. Abstr.* **16**, 157.

DISTILLING OIL.—S. Everett & Carboil Syndicate, Ltd. Brit. Pat. 165,815. *Chem. Abstr.* **16**, 335.

PITCH, ASPHALT AND BITUMEN.

THE NATURAL HYDROCARBONS GILSONITE, ELATERITE, WURTZILITE, GRAHAMITE, OZOKERITE, AND OTHERS.—R. B. Ladoo. *Bur. Mines Repts. Investigations* 2121. *Chem. Anstr.* **15**, 3390.

THE MCMURRAY TAR SANDS OF ALBERTA.—*Petr. Times* **6**, 104. *Chem. Abstr.* **15**, 3391.

ASPHALTS AND ALLIED SUBSTANCES.—2nd Edition. H. Abraham. D. van Nostrand Co., New York.

ASPHALT AND RELATED BITUMENS IN 1920.—K. W. Cottrell. *U.S. Geol. Surv. Mineral Resources of U.S.* 1920. Part 11, 45.

ATHABASKA TAR SAND VERY RICH.—H. L. Stewart. *Oil Paint and Drug Reporter, Petr. Sec.* **100**, (24), 11.

BALKASH "SAPROPELITE."—L. Litinsky. *Petroleum* **17**, 437. *Chem. Abstr.* **15**, 3739.

SYRIAN ASPHALT.—F. Konig-Hietzing. *Petroleum* **17**, 1259. *J. Soc. Chem. Ind.* **41**, 3A.

A CHEMICAL INVESTIGATION OF THE ASPHALT IN THE TAR SANDS OF NORTHERN ALBERTA.—V. K. Kreible & W. F. Seyer. *J. Am. Chem. Soc.* **43**, 1337. *Chem. Abstr.* **15**, 4000.

ASPHALT.—*Mineral Ind.* **29**, 50. *Chem. Abstr.* **15**, 4047.

RELATIONS BETWEEN ASPHALT AND COAL.—J. Marcusson. *Mitt. Material-prufungsamt* **38**, 307.

PATENTS.

ASPHALT-CEMENT MIXTURE ADAPTED FOR USE IN SHEET FORM.—A. L. Clapp. U.S. Pat. 1,379,590. *Chem. Abstr.* **15**, 3381.

ASPHALT MIXTURE ADAPTED FOR PAVING, ETC.—E. L. Sharpneck. U.S. Pat. 1,379,052-3. *Chem. Abstr.* **15**, 3381.

WATERPROOFING CONCRETE.—R. G. Osborne. U.S. Pat. 1,383,749. *Chem. Abstr.* **15**, 3733.

ASPHALT PAINT.—Tada. Jap. Pat. 36,946. *Chem. Abstr.* **15**, 3757.

HYDROGENATING AND DISTILLING HYDROCARBONS FROM BITUMINOUS SUBSTANCES.—A. E. O'Dell. Brit. Pat. 171,785. *Oil Engineering and Finance* **1**, 58.

MANUFACTURE OF ASPHALT.—H. R. Wardell. Assr. to Central Commercial Co. U.S. Pat. 1,385,511. *J. Soc. Chem. Ind.* **41**, 5A.

GAS AND OTHER PRODUCTS FROM PETROLEUM PITCH.—K. Nomi. U.S. Pat. 1,386,945. *Chem. Abstr.* **15**, 3905.

ASPHALT.—H. R. Wardell. U.S. Pat. 1,385,511. *Chem. Abstr.* **15**, 3905.

ROOFING MATERIAL.—H. F. Weiss. U.S. Pat. 1,387,219. *Chem. Abstr.* **15**, 4045.

BUILDING FELT.—R. P. Perry. U.S. Pat. 1,386,277. *Chem. Abstr.* **15**, 4045.

FIRE-RESISTING ASPHALT OR LIKE HYDROCARBONACEOUS MATERIAL.—J. H. Young. Assr. to H. H. Robertson & Co. U.S. Pat. 1,398,991. *J. Soc. Chem. Ind.* **41**, 48A.

BITUMEN AND MINERAL OIL.—M. E. Fyleman. Brit. Pat. 163,519. *Chem. Abstr.* **16**, 160.

FORMING ASPHALT FROM PETROLEUM RESIDUE.—V. C. Illing & J. Kelly. Brit. Pat. 163,656. *Chem. Abstr.* **16**, 160.

DISTILLING PETROLEUM OILS; ASPHALTS.—V. C. Illing & J. Kelly. Brit. Pat. 163,363. *Chem. Abstr.* **16**, 161.

ASPHALT PAVING.—W. J. Mellersh-Jackson. Brit. Pat. 167,997. *Chem. Abstr.* **16**, 327.

MOLDING AND ENCASING ASPHALT FOR SHIPMENT AND HANDLING.—F. C. Overbury and C. E. Ruhr. U.S. Pat. 1,391,969. *Chem. Abstr.* **16**, 340.

PARAFFIN, OZOKERITE AND VASELINE.

COMMERCIAL CERESINS.—F. Kirchdorfer. *Seifensieder Zeit.* **48**, 317, 385, 364, 457, 481, 508, 528.

THE SOLIDIFICATION INTERVAL OF PARAFFINS.—K. Fricke. *Chem. Zeit.* **45**, 891. *Chem. Abstr.* **16**, 338.

THE SOLID PARAFFINS IN PETROLEUM.—M. A. Rakusin. *Petroleum* **18**, 5, 42. *J. Soc. Chem. Ind.* **41**, 129A.

ORIGIN OF PETROLEUM.

NOTES ON THE PRESENCE AND ORIGIN OF THE PETROLEUM OF ARGENTINA AND BOLIVIA.—R. Anderson. *Anales soc. quim. Argentina* **8**, 1. *Chem. Abstr.* **15**, 3601.

VEGETABLE BITUMEN OF RECENT FORMATION.—*Oil Engineering and Finance* **1**, 140.

PHYSICAL PROPERTIES OF PETROLEUM AND ITS PRODUCTS.

REFRACTIVE INDEX OF ROUMANIAN PETROLEUM.—C. Predescu. *Bull. sec. sci. acad. Roumaine* **6**, 150. *Chem. Abstr.* **15**, 3389.

SPECIFIC INDUCTIVE CAPACITY OF ROUMANIAN PETROLEUMS.—C. Predescu. *Bull. sec. sci. acad. Roumaine* **6**, 156. *Chem. Abstr.* **15**, 3389.

STUDIES IN EMULSIONS. III. FURTHER INVESTIGATION ON THE REVERSAL OF TYPE BY ELECTROLYTES.—S. S. Bhatnagar. *J. Chem. Soc.* **119**, 1760. *J. Soc. Chem. Ind.* **41**, 22A.

VISCOSITY-TEMPERATURE CURVES OF FRACTIONS OF TYPICAL AMERICAN CRUDE OILS.—E. W. Dean & F. W. Lane. *J. Ind. Chem. Eng.* **13**, 779. *Chem. Abstr.* **15**, 3902.

THE VAPOUR PRESSURE OF MIXTURES.—A. W. Porter. *Trans. Faraday Soc.* **16**, 336. *Chem. Abstr.* **15**, 3785.

COMMON CHARACTERISTICS OF CRUDE PETROLEUM-EMULSIONS.—E. E. Ayres. *Petr. World* **18**, 406. *Chem. Abstr.* **15**, 3903.

THE DIMENSIONS OF THE MOLECULES OF THE FATTY OILS AND CERTAIN PHENOMENA OF MOLECULAR SOLUTION.—P. Woog. *Compt. rend.* **173**, 387. *Chem. Abstr.* **16**, 5.

SURFACE TENSION OF MONOMOLECULAR LAYERS.—A. Marcelin. *Compt. rend.* **173**, 38. *Chem. Abstr.* **16**, 186.

Inflammability of Fractions of Roumanian Petroleum.—C. Predescu. *Bull. sec. sci. acad. Roumaine* **7**, 16. *Chem. Abstr.* **16**, 336.

Viscosities and Pour Tests of Typical Crude Oils from the Eastern and Rocky Mountain Producing-Fields of the United States.—E. W. Dean, A. D. Bauer & W. B. Lerch. *U.S. Bur. of Mines Repts. Investigations* 2290.

Properties of Typical Crude Oils from the Producing Fields of Northern and Central Texas, Northern Louisiana and Arkansas.—E. W. Dean, M. B. Cooke & C. R. Bopp. *U.S. Bur. Mines Repts. Investigations* 2293.

Chemistry of Petroleum.

Development of an Oil By-Product Industry.—E. K. Rideal. *Chem. Age* **4**, 666. *Chem. Abstr.* **15**, 3389.

Action of Micro-Organisms on Crude Petroleum.—J. Rausz. *Petroleum* **14**, 553. *Abstracts Bact.* **3**, 335. *Chem. Abstr.* **15**, 3552.

Importance of the Olefine Gases and their Derivatives. III. Ethylene Dichloride.—G. O. Curme, Jr. *Chem. Met. Eng.* **25**, 999.

Importance of the Olefine Gases and their Derivatives. IV. Isopropanal (Isopropyl Alcohol).—G. O. Curme, Jr. & E. W. Reid. *Chem. Met. Eng.* **25**, 1049.

Importance of the Olefine Gases and their Derivatives.—V. Ethylene Chlorhydrin and Ethylene Oxide.—G. O. Curme, Jr. & C. O. Young. *Chem. Met. Eng.* **25**, 1091.

Preparation of a Petroleum from a Vegetable Oil.—A. Mailhe. *Compt. rend.* **173**, 358. *Chem. Abstr.* **15**, 3739.

Problems in the Improvement of Hydrocarbons.—R. Kötschau. *Z. angew. Chem.* **34**, 403. *Chem. Abstr.* **15**, 4006.

Colloid Chemistry of Petroleum.—F. W. Padgett. *Chem. Met. Eng.* **25**, 189. *Chem. Abstr.* **15**, 4047.

Iodine Numbers of Unsaturated Hydrocarbons and Cracked Gasolines.—W. T. Faragher, W. A. Gruse & F. H. Garner. *J. Ind. Eng. Chem.* **13**, 1044. *J. Soc. Chem. Ind.* **41**, 90A.

Relation between the Molecular Properties and the Capacity for Fixation of Iodine of Certain Hydrocarbons.—P. Woog. *Compt. rend.* **173**, 1471. *J. Soc. Chem. Ind.* **41**, 90A.

Possibilities of Chemical Research in Producing Branch of Oil Industry.—H. H. Hill. *Petr. Times* **7**, 241.

Total Energy of Roumanian Petroleum and its Partition in the Petroleum Fractions.—A. Predescu. *Bull. sec. sci. acad. Roumaine* **7**, 18. *Chem. Abstr.* **16**, 336.

Composition of Petroleum and its Relation to Industrial Use.—C. F. Mabery. *Am. Inst. Min. and Met. Eng.* Separate No. 1088. *Min. and Met.*, Aug., p. 18. *Min. and Met.*, Feb., 1920, No. 34.

Petroleum as a Substitute for Oleomargarine.—*Petr. World (Los Angeles)* **6**, 20.

Patents.

Chlorinating Hydrocarbons.—F. Sparre & W. E. Masland. U.S. Pat. 1,379,367. *Chem. Abstr.* **15**, 3392.

Chlorinating Paraffin Hydrocarbons.—G. T. Koch & A. L. Stallkamp. U.S. Pat. 1,380,067. *Chem. Abstr.* **15**, 3393.

Preparing Drying Oils from Hydrocarbons.—H. A. Gardner & E. Bielouss. U.S. Pat. 1,384,447. *Chem. Abstr.* **15**, 3757.

Drying Oil made from Saturated Hydrocarbons.—E. Bielouss. U.S. Pat. 1,384,423.

Apparatus for Producing Tetrahalogenated Hydrocarbons.—W. H. Rodebush. U.S. Pat. 1,402,317. *J. Soc. Chem. Ind.* **41**, 157A.

Production of Halogenated Hydrocarbons.—A. A. Backhaus. Assr. to U.S. Industrial Alcohol Co. U.S. Pat. 1,402,236. *J. Soc. Chem. Ind.* **41**, 157A.

Preparation of Fatty Acids, Aldehydes, and Ketones from Mineral Oil Hydrocarbons and Tar Oils.—C. Harries. Ger. Pat. 339,562. *J. Soc. Chem. Ind.* **41**, 35A.

Oil Gas and Petrol Gas.

Thermal Efficiency of Oil-Gas Sets.—E. L. Hall & S. H. Graf. *Gas Age Record* **48**, 409. *Am. Gas J.* **115**, 318, 328. *Chem. Abstr.* **16**, 330.

Patents.

Oil Gas Producer.—E. A. West & E. E. Parsons. U.S. Pat. 1,386,038. *Chem. Abstr.* **15**, 3902.

Apparatus for Protecting (Oil) Gas Producers.—W. C. Dayton. Assr. to Oil Gas Corp. U.S. Pat. 1,402,721. *J. Soc. Chem. Ind.* **41**, 131A.

Miscellaneous.

The Nomenclature of Petroleum Products.—F. Bordas. *Ann. fals.* **13**, 89. *Chem. Abstr.* **15**, 3389

Petroleum as the Foundation of a Chemical Industry in Poland.—*Petr.* **17**, 332.

Recent Articles on Petroleum and Allied Substances.—E. H. Burroughs. *U.S. Bur. Mines Repts. Investigations* 2284 and 2305.

Power Transmission by Oil.—H. S. Hele-Shaw. Institution of Mech. Engineers. *Petr. World* **19**, 76. *Oil Engineering and Finance* **1**, 59.

Oils, Fats and Fuels.—T. Hull. Blackie and Son. London.

Anglo-American Co-operation in Oil.—Interview with Sir J. Cadman. *Oil Engineering and Finance* **1**, 93.

Quantitative Survey of the Petroleum Industry.—Van H. Manning. *Petr. Times* **7**, 165.

RUST PREVENTION BY SLUSHING.—H. Styri. *Trans. Am. Electrochem. Soc.* **40**. *Chem. Abstr.* **15**, 3973.

PETROLEUM AND NATURAL GAS.—D. T. Day. *Mineral Ind.* **29**, 489. *Chem. Abstr.* **15**, 4047.

THE CURRENT YEAR IN THE PETROLEUM INDUSTRY.—W. C. Teagle. *Oil Paint and Drug Reporter, Petr. Sec.* **100**, (28), 11.

OIL PRODUCTION DURING THE PAST YEAR AND A GLIMPSE AT THE FUTURE.—F. Haskell. *Oil Paint and Drug Reporter, Petr. Sec.* **100**, (28), 13.

THE OIL ENCYCLOPEDIA.—M. Mitizkis. Chapman and Hall, London.

OIL: ITS INFLUENCE ON POLITICS.—F. Delaisi. Labour Publishing Co., Ltd., London.

MINING LANDS AND OIL RESOURCES.—H. G. Morris. *Oil Engineering and Finance* **1**, 245.

PETROLEUM TECHNOLOGY AT THE BIRMINGHAM UNIVERSITY.—*Oil Engineering and Finance* **1**, 253.

ELEVENTH ANNUAL REPORT OF THE DIRECTOR OF THE U.S. BUREAU OF MINES FOR THE FISCAL YEAR ENDED JUNE 30, 1921.—*Petr. World* **19**, 106.

MANUAL FOR THE OIL AND GAS INDUSTRY UNDER THE REVENUE ACT OF 1918.—U.S. Treasury Department. Internal Revenue Bureau.

SYNTHETIC GASOLINE A FACT ?—*Petr. Age* **8**, Dec. 1, 26.

DICTIONARY OF OIL TERMS.—*Atlantic Connecting Rod* **13**, Aug.

PATENTS.

MINERAL OIL MIXTURE FOR USE IN PAINTS.—W. N. Blakeman, Jr. U.S. Pat. 1,385,035. *Chem. Abstr.* **15**, 3757.

PAINT OIL MIXTURE.—W. N. Blakeman, Jr. U.S. Pat. 1,385,036. *Chem. Abstr.* **15**, 3757.

HYDROGENATED MINERAL OIL IN PAINTS.—W. N. Blakeman, Jr. U.S. Pat. 1,385,037. *Chem. Abstr.* **15**, 3757.

Abstracts.

Compiled by S. Bowman, A.I.C.

A Chemically-Controlled Automobile.—G. G. Brown. *J. Ind. Eng Chem.*, 1922, **14**, 6–12.

In view of the increasing consumption of petrol and the uncertainty of future production the author lays emphasis on the need of more economical use of that fuel and indicates how such a saving can be effected by the application of chemical engineering principles.

Whereas the efficiency of a properly controlled internal-combustion engine may well be 30–35%, the average obtained is seldom more than 15%, and the Bureau of Mines is quoted having found that "the combustible gas in the average automobile exhaust from one gallon of gasoline amounts to 30% of the total heat in a gallon of gasoline."

This state of affairs is due, in the opinion of the author, to the fact that manufacturers have depended on mechanical improvements for increased efficiency rather than the consideration of the chemical and physical reactions taking place in the engine itself.

A detailed study of the thermodynamics involved is given, and efficiency $E=1-(\frac{1}{r})^{K-1}$, where $r=$ compression ratio, and K ratio of sp. hts; compression ratio being fixed by engine design and K depending on mixture ratio. The thermal efficiency due to compression ratio and mixture proportion is shown graphically, higher compression giving higher temperature and more rapid explosion, and lean mixtures having lower specific heats reducing radiation losses.

Reaction velocity, also an important factor, is shown to be influenced by (*a*) concentration, determined by the law of mass action; (*b*) temperature, depending on mixture proportion; (*c*) turbulence, depending on size of valve, speed of engine, etc. Incomplete combustion may take place, resulting in the formation of aldehyde, carbon monoxide, and possibly hydrogen. The stability of paraffins varies inversely as the molecular weight. Ethane is rapidly decomposed at 1100° C., and at 1500° C. ·036 sec. is the time required for complete decomposition of the hydrocarbons, this time being of the same order as that of the ignition period. The experimental work was carried out by means of an engine connected to a hydraulic dynamometer, speed taken by a counter and torque determined by balancing the arm of the dynamometer on the platform of a Fairbank's scale. The composition of the exhaust gases was determined in an Orsat apparatus and runs made under all possible variables. A special automatic carburetter, acting as a governor, has been devised, and is described, and numerous curves and indicator diagrams are given.

The author summarises his investigations :—

"The combustion or explosion of a gasoline-air mixture is essentially a complex chemical reaction, and, as such, is susceptible to chemical control. The most important consideration is the velocity of reaction, which is determined by concentration, turbulence and temperature, as follows :—

"1. The mixture of maximum reaction velocity has always an excess of combustible over the combining proportions, and the wider the variation from this ratio the lower the reaction velocity.

"2. Turbulence increases the reaction velocity.

"3. As the temperature is raised, the velocity of reaction is increased. As the greatest efficiency is obtained with the most dilute mixture that can be burned under existing conditions, it follows that the greatest mileage can be obtained with dilute hot mixtures with a high degree of turbulence.

"As the temperature decreases the mixture must be made more concentrated to maintain the velocity of reaction. Since turbulence decreases as the engine speed decreases the reaction velocity must be maintained by increasing the concentration of the mixture as greater load in put on the engine."

Viscosity-Temperature Curves of Fractions of Typical American Crude Oils.—E. W. Dean & F. W. Lane. *J. Ind. Eng. Chem.*, 1921, **13**, 779–86.

Crude oils representing paraffin, asphalt, and mixed base oils were fractionated by the Bureau of Mines method and the fractions examined by means of the Ostwald viscometer at temperatures between 0° and 100° C. Variation of viscosity with temperature appeared to be least in the case of paraffin base oil and greatest with asphalt base oil.

Degree of Unsaturation of Mineral Oils in the Bergius (Hydrogenation) Process.—H. I. Waterman & J. N. J. Perquin. *Rec. Trav. Chim.*, 1921, **40**, 677–680.

An oil treated by the Bergius process at 400° C. and 100 atm. gave a residue of 57·6% at 300° when distilled by Engler's method, whereas the oil before treatment gave a residue of 83·8% at that temperature. The iodine value as determined by the Hanus method showed slightly more unsaturation in the case of the treated oil, but in both cases was largely dependent on proportion of iodine solution taken.

The Technical Purification of Crude Naphthenic Acids.—H. Burstin & B. Spanier. *Petroleum*, 1921, **17**, 1329–1334.

Distillation with 30% to 60% of superheated steam at a reduced pressure gave a product having an acid value 126, sapon. value 142, and 13% of unsaponifiable matter. The sodium and calcium salts of the naphthenic acids being decomposed by CO_2 it is suggested that a method of refining may be employed based on the use of lime kiln gas or flue gas.

The sodium carbonate formed to be recausticised and the calcium carbonate in turn used for production of CO_2.

The reaction between CO_2 and sodium naphthenate is, however, a reversible one and limited to that extent.

THE SEPARATION OF ADHERENT OIL OR BITUMEN FROM ROCK.—E. Fyleman. *J. Soc. Chem. Ind.*, 1922, **41**, 14–16T.

A method is described for the recovery of oil or bitumen from mineral matter in deposits other than those found in Trinidad. Such deposits exist in large quantities in various parts as natural geological formations and also as by-products of oil-producing areas. The most important of these are the tar sands which occur in enormous quantities in Alberta. The sand contains 10–20% bituminous matter, which yields on heating 15–25 gall. of oil per ton, the latter giving 5% of gasoline on distillation. Other deposits are those existing in the neighbourhood of oil wells, where the surrounding soil has become more or less saturated due to leakage, etc.

The method of recovery depends on the reduction of surface energy of the system by the addition of some liquid of low surface tension, such as an aqueous soap solution. When such a solution is added to the mixture of sand and bitumen or oil the molecular adhesion is destroyed and the mineral matter separates out clean, according to the efficiency of the agitation provided.

In the case of oil and sand separation takes place in the cold, but with bitumen heating to 80° C. is required to produce necessary fluidity. Very small concentrations of soap solution are required, one part per thousand being ample, and where the organic matter present is acidic in character, soda ash may be employed in lieu of soap, as the latter would be formed in consequence. Gentle stirring is required to ensure thorough wetting of all the particles, and segregation rapidly takes place, the sand separating in a clean state, and the bitumen or oil with a 10% water content. The soap solution is run off and used indefinitely. The method is not applicable to such deposit as those found in Trinidad, on account of the fine state of division of the mineral matter present. Details of costs of treatment are given.

SOME NEW PETROLEUM PRODUCTS.—J. H. James. *Chem. Met. Eng.*, **26**, 209–212.

An attempt is made to oxidise the less valuable products of petroleum, in the vapour phase by the aid of catalysts at a comparatively low temperature, and to utilise the various oxidation products obtained for industrial purposes.

The catalytic material employed are the oxides of molybdenum and uranium or such a compound as diuranyl vanadate. These are employed in three layers or screens, the mixture of hydrocarbon vapour and air, for instance, being passed successively through a thin layer of uranium oxide and then through two separate layers of molybdenum oxide.

Uranium oxide appears to have marked properties for oxidising to the aldehydic stage, so that when acids are desired as the main product this preliminary step gives a higher yield. The temperature limits of reaction are 240° C.—500° C., so that where the higher fractions are dealt with dilution with a more volatile fraction is necessary to ensure vaporisation at the desired temperature.

The products formed vary with the conditions of working, but in general represent all the stages of oxidation from alcohols to oxygenated acids. Although the chemical nature of these oxidised hydrocarbons has not been studied in detail, the acids are decidedly aldehydic in character and bear no resemblance to the true fatty acids. On saponification with caustic soda considerable resinification takes place and the liberated acids separate out as hard resins. On the other hand, if lime is used instead of soda little resinification takes place and the product is suitable for grease making. A heavy Mexican fuel oil on treatment gave an "oxidised" kero S.G. ·863 and cal. val. 18,696 B.T.U., and found suitable for use in internal-combustion engines.

Southcome's germ theory of lubrication suggests the use of these oxidised acids in lieu of fatty acids for blending purposes. Further, the treated oil has decided frothing properties and is suggested for use in oil flotation.

Iodine Numbers of Unsaturated Hydrocarbons and Cracked Gasolines.—W. F. Faragher, W. A. Gruse, & F. H. Garner. *J. Ind. Eng. Chem.*, **13**, 1044–1049.

A comparison of Wijs' and Hanus, methods when used for cracked spirit is made. Whereas the Hanus method is more likely to indicate the true degree of unsaturation, Wijs' method depends to a great extent on the proportion of reagent used to amount of spirit taken and a large excess of reagent is always necessary. When dealing with quantities of less than 0·1 grm. there appears to be little difference between the two methods.

The presence of diolefines are indicated by a characteristic curve, showing variation of iodine value with time of reaction and the amount of reagent used.

The Hanus reagent does not form substitution compounds with simple or cyclic paraffins, aromatics, olefines or diolefines.

The Solid Paraffins in Petroleum.—M. A. Rakusin. *Petroleum*, **18**, 5–9, 42–48.

Experiments were made with a Grosny crude which contains a high percentage of solid paraffins. Various methods were tried, such as centrifuging, filtration through Chamberland and Pukal filters, and also the effect of absorbing materials such as kaolin and fuller's earth, etc., under varying conditions of temperature and pressure. Although complete extraction was not attained, centrifuging followed by filtration through fuller's earth gave the best results. Centrifuging removed 2·6%

of m.p. 60° C., sp. gr. 0·8974; fuller's earth absorbed ·95% of m.p. 50° C., sp. gr. 0·8108; leaving 1·7% of m.p. 59° C., sp. gr. 0·8377, which could only be removed by Holde's distillation method.

The solid paraffins extracted by the above method showed a distinct crystalline structure under the microscope, thereby refuting the theory that such bodies originally exist in an amorphous state and only undergo crystallisation on heating.

Apparatus and Method for the Determination of Resistance to Cold of Mineral Oils.—K. Glaser. *Petroleum*, **18**, 81–82.

The apparatus consists of an outer vessel filled with ice surrounding an inner vessel containing a freezing mixture, thermometer, and stirring gear. Above this is fixed another vessel partly filled with water from which is suspended a number of glass siphon tubes the upper ends of which dip into the water and lower end bent U-shape and graduated immersed in the freezing mixture. The oils are contained in the graduated portion of the siphon tubes and cooled at —10° C. for one hour. The water level in the upper vessel is then raised 50 mm. by means of a displacement body and simultaneously a stop-watch started. After 1 min. the siphons are withdrawn and the rise in the level of the oil noted.

The Total Energy of Roumanian Petroleum and Its Partition in the Fractions.—C. Predescu. *Bull. sec. sci. acad. Roumania*, **7**, 18–22.

Campina crude oil sp. gr. 0·8671, was fractionated into 10° fractions, and the calorific values found to range from 11,823 cals. for the 60°–70° fraction to 10,409 for the residue boiling above 350° C., the decrease being regular throughout. The method employed in the case of the more volatile fractions was to cover the platinum capsule with a weighed piece of thin sheet rubber fixed by a weighed rubber band, the heat of combustion of which were determined in a blank experiment. Covering the capsule in this manner showed no loss in weight after standing 30 mins. at room temperature.

The Solidification Interval of Paraffin.—K. Fricke. *Chem. Zeit.*, **45**, 891–2.

Paraffin wax exhibits a certain amount of plasticity during the interval of solidification, which causes the candles to stick to the moulds and also to bend over at high room temperatures. As this property is not indicated by the usual methods for determining solidification temperature Fricke employs the following method.

100 grms. of the wax is melted in a porcelain dish on a water bath at a temperature below 65° C. When completely melted the clear liquid is poured into a shallow pan, 6+11+3 cm. and a thermometer bulb immersed therein. The temperature of the room during the experiment and also the time required for the wax to drop to 60° C. are noted. After 50 mins. the hardness of the wax is tested by means of a plunger having a cross section of 1 sq. cm. and weighted to 2·2 kgm. If an

impression is made further tests are made at 2 min. intervals until the plunger fails to make an impression which can be seen or felt, this being noted as the time of complete solidification. The interval of solidification is the total time from that at which the wax was at 60° C. to the time of complete solidification, and for suitable candle-making should be not more than 65 mins.

A Study of the Saturated and Unsaturated Oils from Shale.—C. W. Botkin. *Chem. and Met. Eng.*, **26**, 398–401.

Previous work by the author is reviewed, showing that certain crude shale oils containing 12 to 40% of saturated compounds—i.e., unabsorbed by cold concentrated sulphuric acid, decompose on distillation at atmospheric pressure into gas, coke, and a lighter oil containing 15 to 83% more saturated compounds. This phenomenon being the reverse of what usually happens on cracking of petroleum, further experiments were made with a more varied range of crude shale oils, including examples obtained from Scotch and English shale. 50 to 100 c.c. of each crude was distilled from a Pyrex flask down to hard coke at a uniform rate of 1 drop per sec., and the percentage of distillate (water and oil), coke, and gas carefully ascertained in each case. The results, together with the characteristics of the distillates, are tabulated and compared.

A nitrogen determination was also made before and after distillation by a modified Kjeldahl-Gunning method. 2–3 grms. of the oil are digested in a 650 c.c. Kjeldahl flask with 10 grms. potassium sulphate, 0·3 grms. anhydrous copper sulphate and 45 c.c. of 96% sulphuric acid. After complete decomposition the flask is cooled, 300 c.c. of water added, cooled and a small piece of paraffin wax added to prevent frothing. Excess of sodium hydrate solution is gently run in, together with a few grains of zinc and distillation made in the usual manner into 0·1 N sulphuric acid.

In all cases distillation of the crude shale oil had the effect of increasing the percentage of saturates and decreasing the nitrogen content, the change being the most marked in those crudes with a high unsaturated content.

The characteristics of the lighter fractions up to 210° C. contained in the original crude (primary gasoline), and also after distillation (secondary gasoline), are compared, and although the conditions of retorting the shale differed considerably, the secondary gasoline in all cases showed an increase in saturates, but otherwise closely resembled the primary fraction. This might be expected, since both are decomposition products, the primary gasoline being produced in the retort and the secondary by decomposition in the still. The heavier fractions of the crude oil were similarly examined and found to contain the most unstable bodies, which readily decomposed on heating, producing a more saturated distillate. The experiments made seem to indicate that crude shale oils are apparently composed of comparatively light stable oils of higher

saturation produced by decomposition during retorting and of heavy unstable oils of lower unsaturation that have escaped decomposition in retorting because of rapid removal as vapour and fog by the gases and lighter oils. The decomposition from kerogen to once-run oil tends to occur in two stages—a primary decomposition in which the insoluble kerogen is changed, possibly by depolymerisation into soluble heavy unstable compounds similar to the shale oil residue; and a secondary decomposition (not depolymerisation) in which these unstable compounds are broken down in lighter oils of greater stability and saturation such as constitute the once-run oils. Retorting with steam and inert gases tends to prevent the secondary decomposition by carrying over larger amounts of the bitumen produced by the primary decomposition and, as a result, the crude oil contains a higher percentage of unstable unsaturated compounds. Distillation of the shale or crude oil at a slow rate causes a more complete secondary decomposition and produces an oil of the once-run type. Much of the so-called high temperature retorting evolves the products so rapidly that the lighter oil and gases carry large proportions of the primary products out of the hot zone before secondary decomposition has progressed far and the crude oil is consequently more highly unsaturated. It is evident that physical conditions during retorting can be so controlled as to obtain a maximum of the bituminous products or an oil similar in quality to once-run oils, in which secondary decomposition is complete, and that consideration of these two stages of the decomposition is important in the construction and operation of retorts on a commercial scale.

Patents.

Hydrogenating and Distilling Hydrocarbons from Bituminous Substances.—A. E. O'Dell. E.P. 171,785, Nov. 23, 1921.

Bituminous sands, e.g. Alberta Tor Sands are intimately mixed with hydrogen under pressure, while in the molten state, fed into continuous stills and the volatile matter distilled off and condensed in an atmosphere of hydrogen. The latter is obtained by the decomposition of natural gas.

Method of Treating Oil Shales.—S. H. Dolbeor. E.P. 171,918, Dec. 1, 1921.

Pulverised shale is mixed with water, a small quantity of oil and aerated to produce a froth and effect flotation separation of organic matter present. An addition of an electrolyte such as sulphuric acid may be necessary.

Separation of Solid and Liquid Hydrocarbons.—Deutsche Erdöl Aktiengesellschaft. E.P. 149,347, Dec. 21, 1921.

A process is described for separating solid hydrocarbons from liquid hydrocarbons which consist in liquefying the mixture to be separated by heating and treating the liquefied mixture in counter current with a

solvent in which the solid hydrocarbons are practically insoluble but the liquid hydrocarbons soluble.

PROCESS FOR DECOMPOSING HEAVY HYDROCARBON OIL INTO LIGHTER OILS. R. D. George. E.P. 151,925, Sept. 14, 1920.

The process consists of subjecting heavy oil to a cracking temperature in a state of rapid motion through an apparatus forming a closed cycle under constant temperature and pressure conditions. The oil passes into a vertical cracking tube fitted with rotating scraper and from there to a series of separators. After deposition of carbon the oil is returned to the cracking tube, together with fresh preheated oil required to replace volatilised portions and separated carbon withdrawn at intervals.

CRACKING OF OILS.—R. H. Brownlee & C. F. de Ganahl. E.P. 173,242, June 21, 1920.

The oil is heated to the required temperature in a still or series of stills, consisting of a revolving drum containing a number of metal balls. These may be of iron or steel or some metal possessing catalytic properties, and should be hollow to give necessary surface area without undue weight. Their action is to increase the heating surface and also to effect a pulverising action on the residue as it becomes solid.

MANUFACTURE OF GASOLINE.—A. McD. McAfee. U.S.P. 1,405,054, July 12, 1918.

Gas oil is continuously distilled in the presence of anhydrous aluminium chloride added in the form of a thin mixture with the oil at 150° F. Agitation is provided and the spent aluminium chloride separates out as a sludge and is removed periodically, for recovery. The gasoline is obtained at suitable condensing temperatures.

PURIFICATION OF PETROLEUM OILS.—J. J. Hood. U.S.P. 1,404,293, July 22, 1919.

The vaporised oil is passed over granular magnesite maintained at a temperature above that of the boiling range of the liquid. Decomposition of the sulphurous compounds is effected and the gaseous sulphur compounds formed are absorbed by suitable materials such as oxide of iron, etc.

APPARATUS FOR REFINING HYDROCARBONS.—W. O. Snelling. U.S.P. 1,402,455, Jan. 3, 1922.

Consists of a vertical reaction chamber with external heating placed beneath and connected to a liquid reservoir by means of a vaporising chamber. Pressure is established in the reaction chamber by equalising the pressure above and below the liquid in the upper reservoir and restraining the outflow of vapour and gases evolved.

METHOD OF PURIFYING OILS.—C. M. Alexandra. Assr. to Gulf Refining Co. U.S.P. 1,402,733, Jan. 10, 1922.

A mixture of oil and sulphuric acid is passed continuously through a temperature-controlled conduit, mechanical agitation being provided.

By this means the minimum amount of acid can be employed for oxidation purposes without undue loss or polymerisation of hydrocarbons.

PRODUCTION OF LOW-BOILING POINT SATURATED HYDROCARBONS FROM HEAVY HYDROCARBON OILS.—A. S. Ramage. Assr. to F. F. Read. U.S.P. 1,403,194, Jan. 10, 1922.

The vaporised heavy oil mixed with steam is passed over an iron compound maintained in the ferrous oxide condition at a temperature of 550° C.

FULLER'S EARTH TREATING PROCESS AND PRODUCT.—R. G. Tellier. U.S.P. 1,402,112, Jan. 3, 1922.

Fuller's earth is roasted in a current of air at a temperature 370–730° C., the mass being constantly turned over.

TREATING SPENT FULLER'S EARTH.—C. I. Robinson. Assr. to Standard Oil Co. U.S.P. 1,403,198, Jan. 10, 1922.

Spent fuller's earth is revivified by washing with isopropyl alcohol of 80% strength.

MANUFACTURE OF MOTOR FUEL.—C. M. Alexandra. U.S.P. 1,407,611, Feb. 21, 1922.

The process consists in passing the vapours of high-boiling petroleum fractions through a cracking zone heated to 500° C. at a speed sufficiently rapid to ensure a substantial portion of the vapour passing through unchanged. The resulting vapours are fractionally condensed, the high-boiling liquid returning continuously to the still.

FRACTIONAL DISTILLING APPARATUS.—A. E. R. Chenard. U.S.P. 1,407,330, Feb. 21, 1922.

The apparatus consists of a boiler or still connected to a series of elongated horizontal units arranged zigzag fashion. Each unit consists of a pair of hollow cones arranged base to base, axis horizontal, through which the vapour circulates. A filtering device is fitted to the outlet end of each unit to collect any entrained liquid which is siphoned off automatically.

METHOD OF TREATING HYDROCARBON OILS.—A. S. Ramage. U.S.P. 1,407,770, Feb. 28, 1922.

The method consists in treating the products obtained by cracking processes or other products rich in olefines with sulphuric acid 60–66° Bé., the proportion of acid being 50% by weight of the olefinic bodies present. The resulting acid tar is then either separated or neutralised *in situ* with an aqueous alkaline solution, the effect of which is to hydrolyse those constituents absorbed by the acid. After separation of the aqueous solution the oil is distilled with the result that the boiling range has been considerably increased by the treatment and compounds of an alcoholic nature formed in addition to the polymerised products.